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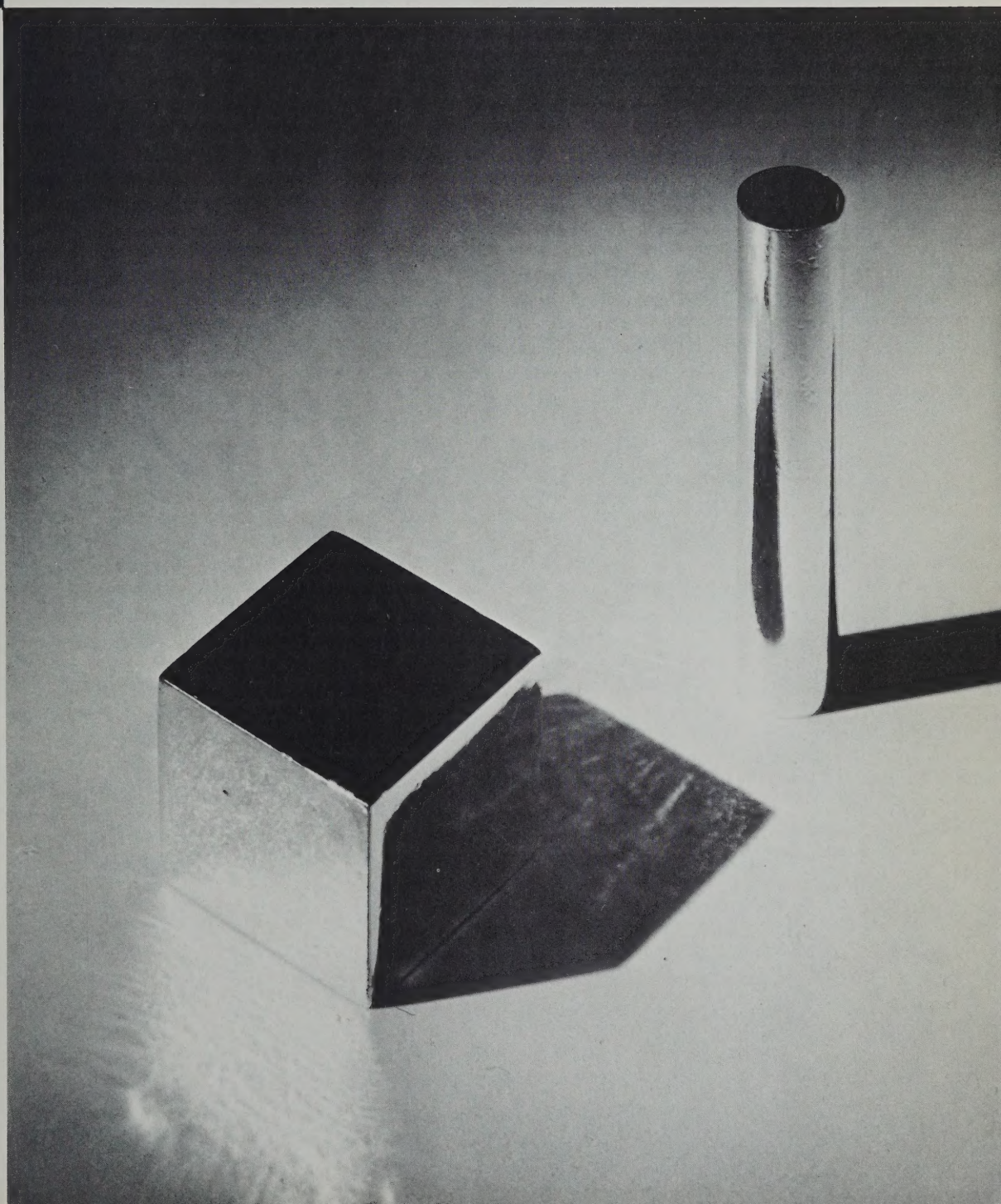
NATIONAL BUREAU OF STANDARDS

Technical News Bulletin



UNITED STATES DEPARTMENT OF COMMERCE

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Technical News Bulletin

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U.S. DEPARTMENT OF COMMERCE
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COVER: *This single crystal cube and polycrystalline rod of Ultra-Purity Aluminum belong to the first of a series of Research Materials now being issued by NBS. This new class of materials will meet the needs of scientists engaged in materials research.* *(See page 243.)*

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology
- Center for Radiation Research
- Center for Computer Sciences and Technology

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MEASUREMENT IN A CHANGING WORLD

On June 15, 1970, Lewis M. Branscomb, NBS Director, opened the 1970 biennial meeting of the National Conference of Standards Laboratories at the Bureau's Gaithersburg, Md., facilities. The following is a condensation of Dr. Branscomb's remarks.

The field of metrology along with every other field of technical endeavor in this country finds itself on the defensive now. But I think it would be a mistake for us to misconstrue that situation: I do not believe that there is any significant diminution in the basic public faith in science or in the importance of the fruits of technology to the national life. But like everything else the measurement standards field is feeling the winds of change, change that will dramatically elevate the importance and the professional standing of the science of measurement. Public awareness of measurement is also, I believe, going to increase.

We are now seeing a dramatic increase in the importance of measurement, for measurement is essential to the wise regulation of technology for the public benefit. The last 15 years have seen science policy focus on the exploitation of our scientific capability through technological application. We have done some fantastic things in that period to enhance our military security, to increase our sources of power production, and perhaps most dramatically, to make possible man's first voyage to the moon.

But the next 10 years will be increasingly characterized by the Government's effort to see that science is used for the benefit of man and that technology is mastered by mankind rather than becoming his master. As a Nation we must learn how to live in harmony not only with nature but also with man's own works, the processes and the products of his technology.

It is obvious that regulation of technology for environmental improvement requires measurements to find out what is happening to the environment, to establish technological alternatives for its management, to determine the levels of pollution that will be acceptable under various circumstances, to trace pollution to its sources, and finally to be the tool for regulating pollution. For it is clear that we cannot eliminate pollution of the environment. The only alternative we have is to determine the level and the character of that pollution in return for the benefits that the polluting technology will provide to us.

The challenge is to find those kinds of pollution that are relatively acceptable in relation to the benefits to be gained. This will require an elaborate process of setting measurements and of regulating the performance of every polluting organization or individual in the society to that standard, and will put great stress on measurements of not only the environment, but of the technological process that produces the pollution. When conflicts over the management of the environment reach the courts, the validity, the credibility of the measurement system will come under judicial review. I believe that in the environmental area our measurement capability leaves very, very much to be desired, and that under a very severe court challenge many of the measurements we make could be shown to a jury to lack the credibility that is required.

Concern over the regulation of technology clearly goes far beyond environmental concerns. There is a very fast change taking place in the public's attitude about safety, and about their pocketbook. Variations in quality control that were once accepted as the natural consequence of the vagaries of mechanical systems are no longer acceptable. Society is now asking that we extract in a routine production basis the quality of technology that we know is in principle possible.

Each new area of concern (environmental pollution, consumer safety and

We cannot eliminate pollution. . . . The challenge is to find those kinds of pollution that are relatively acceptable in relation to the benefits to be gained.

protection, etc.) will reflect itself back through the chain of engineering events. That is, it will not only concern the measurement of the properties of the product or the amount of pollution injected into the environment, but will go right back through production, production engineering, design, research, to conception of the basic ideas.

Thus the measurement system will be called upon to establish not only credibility, but also assurance of accuracy and control. This will force us to face up to a credibility gap in measurement standards work, a gap created by a widespread impression that the processes for assuring measurement coherence too often obscure the purposes, and as a result fail to achieve those purposes. In the interest of conserving our resources, those of us who are in the measurement business need to ask ourselves several questions: What is the purpose of a given measurement? What is the intended user's need? What is his measurement capability? To answer these questions, we need a more effective feedback system. We must get out into the field and find out just what is going on so that we can adapt what we are supplying to what is actually needed and used.

We at NBS must give attention to several different phases of our responsibilities. First, we are responsible for establishing the central basis for physical measurements in the United States—establishing, proving, and maintaining these basic measurement standards in our laboratories. These are essentially the SI quantities—the quantities defined in the international system of measurement. Second, we must work down the measurement chain from these fundamental quantities—mass, length, time, temperature—to the hundreds or perhaps even thousands of practical measurement processes that are needed in today's science and industry, such as cryogenic flow, microwave impedance, plasma thermometry, and many others. Third, we must work on the problem of transferring into the primary laboratories throughout the United States the capability that we generate here. Fourth, we must assure adequate verification that the transfer is sufficiently effective for the user's requirement. This requires an active, outward looking role on our part.

In the environmental area our measurement capability leaves very, very much to be desired.

Now let me give you just a couple of examples out of our recent work to indicate some of the things we are doing in two of those four responsibilities—those having to do with the establishment of standards and their more effective dissemination. With respect to establishment of standards I think we can be very proud of a rate of progress that is at least competitive with, if not leading, current requirements. In length measurement we have recently found a way to stabilize a laser to an accuracy of the order of parts in 10^{12}. This development in fact can be carried a good bit further and we have the prospect of a wavelength standard whose reproducibility is nearly competitive with the reproducibility of the frequency standard itself. Close on the heels of that development is the real likelihood that in the next year or so we will succeed in multiplying the frequency standard all the way up to the optical range, permitting direct comparison of the standard of the meter with the standard of the second. At that point we will have the opportunity, if we wish, of assigning an arbitrary value to the speed of propagation of electromagnetic radiation, and discarding either the standard of length or the standard of time at our convenience. This is an example of how rapidly the scientific basis for measurement is proceeding.

Our laboratories in Boulder are now investigating the feasibility of establishing simultaneity through color television. And the idea is basically a very simple one. The three major networks in New York in transmitting their color pictures have a very accurate $3\frac{1}{2}$ megahertz subcarrier. It is possible to put a modulation on the subcarrier during the blanking interval of time between pictures. There are four lines on the TV screen that are available and one can impress a code on these lines that will transmit a time signal throughout the television network. An encoder attached to the TV set displays numeric time information on the screen. It is then only necessary for a given laboratory to determine once what the phase delay is between its location and the source of this coded signal, in order for the television signal to establish the time difference between the absolute time reference maintained by NBS and the laboratory's local clock, thereby providing a running correction for the local clock as well as a basic time base in hours, minutes, seconds. This is being done experimentally over stations KLZ in Denver and KFBC in Cheyenne, Wyoming. We have permission from the FCC, AT&T and the major TV networks to proceed with the examination of this system with a view to implementation on a national basis.

Now beyond improving the basic standards and means for transferring that standard effectively into the laboratory of the user we must study the whole process of measurement in order to ensure that it serves its intended purpose. Some people think of a measurement as the response of an instrument which couples an operator at one end to a system being measured at the other. But a measurement can only be understood in terms of a total man-device system. Heisenberg, in developing the uncertainty principle, really taught us that there is no meaningful measurement that does not affect the system being measured. And it is very important that we understand in detail the nature of that effect. But we need to go one step further than Heisenberg and recognize that the human beings involved in the measurement system are also an important influence on the measurement

The measurement system will be called upon to establish not only credibility, but also assurance of accuracy and control.

as well as being influenced by it. And we must also incorporate them in our understanding of a measurement.

Now let's consider dissemination. It is the answer to the following question that we seek as a new approach for the dissemination of measurement capability: What procedures, how much work, what kind of control, what performance criteria would be needed to constitute evidence as to the quality of measurements of a laboratory? Practical measurement can be easily described in terms of its elements, the concept of the quantity to be measured, the pertinent physical laws, the various instruments used, the physical standards, the operators and the appropriate procedures, the environment in which the measurement is to be carried out, the computations to be made, and finally the means of establishing parameters of performance.

The measurement process is essentially a production process, the product being numbers—that is, measured values. A well-known characteristic of a measurement process is that repeated measurements of the same thing result in nonidentical numbers. To specify a measurement process involves ascertaining the limiting mean of the process, the variability or imprecision due to imperfections in the system, the possible extent of systematic errors or bias from identifiable sources, and the overall limits to the uncertainty of independent measurements.

The key element is that of obtaining a sequence of measurements of the same quantity. In standards laboratories this is fairly easy to achieve simply by remeasuring one of the laboratory standards as if it were an unknown, or using one or more items typical of the test items for the same purpose. The routine calibration of the same object used as a check standard tells us what the measurement process can do. It is not just a simulation of the calibration process—it is the real thing, without the need for any assumptions. Continued measurement of the check standard provides the basis for the precision statement and correlating its behavior with environmental procedures or other factors enables us to measure or set bounds for possible systematic error. For control of the measurement process, this check standard need not have the stability one would require of members of the standard group. Predictability of its performance is the basic requirement.

The Bureau is considering new approaches for the transfer of measurement capability in selected areas. For example, in voltage standards we are developing procedures for using shippable standards for transferring the value from the national reference group to other primary laboratories. The old practice of moving the customer reference group to NBS for calibration left unanswered the question of whether the group survived the return trip unchanged, and placed the burden for the study of the transfer mechanism on each user.

The first or pilot program of this type was in the calibration of mass where the question of transportability of the standard does not arise. We first established that a state of statistical control existed in our own laboratory. Participating laboratories were required to evaluate their own performance parameters, and with the aid of a pair of kilogram standards borrowed from the Bureau could know to what degree their work would be compatible with others in the system. A fundamental difference from their usual procedures is the emphasis on the continued verification of control within the laboratory and between it and other parts of the measurement system. This tells the laboratory how well it performs—and is more meaningful than a certificate that says how well some standards laboratories performed. The amount of effort is dictated by the measurement needs of the user and not by tradition. Similar efforts, which we call Measurement Analysis Programs, are under way for voltage, resistance, capacitance, temperature, length and several other quantities.

I want to emphasize the fact that any standards laboratory has the same responsibility that we now are increasingly feeling—namely, the assurance of the effective transfer of measurement into the hands of users. And I believe that this requires a relationship between the standards laboratory and the user in which the people and the system are coupled and the standards laboratory has the opportunity and the obligation to evaluate the effectiveness of the user's measurement. Once a standards laboratory is in a position to do that, then that laboratory becomes an effective and indeed an indispensable tool of management. We in the Bureau are finding in the areas of technology regulation that we are increasingly impacting the policy making levels of government which must understand how the measurement system is being realized in areas where technology is to be regulated. And I feel if a standards laboratory in a company is in a position not only to calibrate instruments, but to assess the quality of the job being done by those who are making measurements of importance to the company, particularly those making measurements on the output of the production line, then that standards laboratory becomes an important piece of overall management and technological control in the company.

The measurement standards field is feeling the winds of change, change that will dramatically elevate the importance and the professional standing of the science of measurement.

COMPUTER LOOKS THROUGH MICROSCOPE

NBS Engineer Links Two Devices

A COLLABORATIVE EFFORT between the Bureau and the National Institutes of Health has resulted in linking a microscope with a computer to direct the microscope to record features seen through it. Philip Stein, of the Bureau's Center for Computer Sciences and Technology, Dr. Lewis Lipkin, of the National Institute of Neurological Diseases and Stroke, and Dr. Howard Shapiro, of the National Cancer Institute, designed the scanning system.[1] It will be of use in neuropathological studies, in autoradiograph counting, and as a tool in the design of systems for automating image processing.

The system consists of a microscope, an image plane scanner, a motor-driven stage, a computer, and the necessary interface hardware. It not only scans automatically in the x and y directions on the microscope slide, but can do so repeatedly at sequential z positions to obtain three-dimensional data. The stage moves in 0.6 μm x and y steps and in 0.2 μm z steps; the scanner aperture, corresponding to 0.2 μm on the slide (using a 50× objective), resolves points on the image plane separated by 10 μm.

Computer control of the scan offers a unique feature; the operator can manually position the slide to locate features of interest and can note their locations in the computer memory. When later instructed, the stage can return to within one step in each axis of every position previously noted and the system automatically performs a scan at each. This uses to best advantage the capabilities of both man and the computer.

Scanning Pictorial Material

The Bureau has long been interested in scanning pictorial material for in-

Philip Stein views a slide through a Computer-controlled microscope that he developed in collaboration with NIH. The scan is manipulated by pressing buttons on the operator's console, which interrupts computer control. The microscope offers incandescent and monochromatic light sources and computer control of stage and focus adjustments.

put to digital computers. Devices produced at NBS to accomplish this have been of three types, one a drum scanner [2] and a second using an electrically deflected cathode-ray beam.[3] The new NBS scanner uses a third scanning method, employing a combination of mechanical positioning and magnetically tilted mirrors.

The new scanning system resulted from an NBS program sponsored in 1967 by the National Institute of Neurological Diseases and Stroke and by the National Cancer Institute. Its goal was to develop an instrument that was capable of performing current tasks and also flexible enough for basic research into sensing and processing biological images. Microscope functions to be automated under computer control were: positioning the specimen, focusing, changing illumination wavelength and bandwidth, and scanning portions of the visual field.

Design of Scanning Microscope

The scanning microscope was built on an existing special-purpose microscope frame. It offers a choice of either wide-spectrum or monochromatic light, the illumination desired being switched by a mirror. A fixed portion of the light is passed through a special lens system to a photomultiplier tube to provide a reference for specimen illumination.

Movement of the slide in both the x and the y directions is obtained mechanically from micrometer heads geared to stepping motors, giving 2.5 cm travel in 0.6 μm steps. The computer can cause the position desired to be approached always from the same direction and the movement to end in a jogging motion to minimize bearing hysteresis.

Both x and y scanning of a smaller area can be accomplished by positioning two mirrors that reflect the beam en route to the scanning photomultiplier. The mirrors are mounted on galvanometer coils having shafts at right angles to each other and are driven by converted digital signals from the computer. They scan a 2 mm by 2 mm square in the image plane in a 256 by 256 grid.

The microscope scans along the z axis by means of an incremental motor that is geared to the microscope fine-focus control, which can be moved over a range of 0.2 cm in 0.2 μm steps.

The microscope scanner head contains the scanning mirrors, an aperture, and the photomultiplier tube. The output from this is amplified, filtered of undesired frequency components, and sent to the computer, where it is converted to eight-bit binary form. If quantification of density on a relative scale is desired, the filtered signal, I, is compared with the one from the reference photomultiplier, I_0, and the function $\log \frac{I}{I_0}$ is produced by a network of operational amplifiers and sent to the computer.

Controlling the Scan

The scanner is connected in a closed-loop configuration with a small general-purpose computer that controls the scan. This could enable the system to evaluate each scan point on the basis of results of measurements at the preceding points. The ability to direct the scan along fixed density gradients is important for operation as an edge detector.

The operator can control the microscope system by use of a keyboard that works through the interrupt system of the computer. The lighting and scanning operations are actually under computer control. The keyboard offers fast and slow movement in both directions along the x, y, and z axes and controls the wavelength when a monochromator is used with the light source. Additional buttons start and stop computer programs for scanning, measuring, and recording.

The system computer controls the scan but processing the resulting data requires large computers. At present a high-speed telephone line is the link with an image processing computer.

Application of System

The new microscope scanning system was required not just for medical applications, but especially as a design tool in creating new scanning systems. The manner in which a scanning operation is programmed or simulated on the system can guide the design of a specialized machine for scanning and image processing.

One of the specific applications for which the system was designed is scanning autoradiographs. Cell metabolism is studied in this technique by adding radiographic tracers to the blood serum. After a specified time a blood smear is photographed and the negative is scanned by the microscope, which automatically counts the number of silver grains in an emulsion.

The second application is in the field of neurology, in which tissue must be able to be examined in three dimensions. The scanning system does this and produces data that can be used to form a three-dimensional reconstruction of the tissue scanned.

Another application uses the memory capabilities of the computer that controls system operation to speed one phase of microspectrophotometric analyses. For this the scanning head of the microscope is replaced by a spectrophotometer head and the slide scanned under the operator's control to find areas in which spectrophotometric measurements must be made. The three coordinates identifying each area are retained in the computer memory. In the second step the computer is instructed to return to each area and record the spectrophotometric measurements at all points within it, a tedious and lengthy task for a microscope user. The scanning system does this automatically, changing focus and wavelength by motorized control of the microscope and the monochromator. This uses the operator and the scanning system for the parts of the task that each does best.

[1] Stein, P. G., Lipkin, L. E., and Shapiro, H. M., Spectre II: General-purpose microscope input for a computer, Science **166**, 328-333 (Oct. 1969).

[2] Processing pictorial information on digital computers, Nat. Bur. Stand. (U.S.), Tech. News Bull. **42**, 60-63 (Apr. 1958).

[3] FOSDIC IV reads microfilmed weather data for computer, Nat. Bur. Stand. (U.S.), Tech. News Bull. **51**, 63–65 (Apr. 1967).

Better Resolution in Scanning Micrographs

Images Read for Digital Computers

AN ADVANCED SCANNER now in use at the NBS Institute for Materials Research is automatically scanning micrographs and producing data for metallographic analyses. Called SADIE-III, the scanner was devised by George A. Moore, of the Institute's metallurgy laboratories, under a program supported in part by the National Institutes of Health.[1] This device examines a photographic print or negative of 24 by 24 cm at almost a million discrete points, assigns to each a density value from a 64-level gray scale, and presents an analysis of the data. SADIE's speed of about two minutes for a complete scan and its resolution of a quarter of a millimeter make it extremely useful for metallurgical and biological analyses.

Automatic Scanning

Reading graphical material directly into a computer for processing was a goal of computer pioneers. The Bureau early developed a drum-type scanner called SADIE (Scanning Analog-to-Digital Input Equipment) for use with the Bureau's SEAC (Standards Electronic Automatic Computer).[2] SADIE scanned pictorial material 44 mm square by means of a photomultiplier tube and produced a binary output—ones for dark squares and zeros for light areas.

Although slow by today's standards, SADIE was simple and reliable; it made possible a variety of research programs using first and second generation computers. Included were studies of character reading and pattern recognition, particle counting, and microstructure analysis. In the course of this work computer subroutines were developed to improve pictures degraded by "noise" and to distinguish individual objects in complex patterns. These subroutines were collected in STRIP (Standard Routines for Image Processing), a conversational computer program for digital image processing.

SADIE, SEAC, and STRIP were teamed in several projects. Graphite particles in cast iron were measured far more rapidly than by traditional "manual" methods,[3] aiding in development of new ASTM* charts for graphitic alloys. The amount of an alloy phase responsible for superconductivity was measured from color separation prints of color micrographs.[4] Similar techniques were used to identify and count specific cells for biological studies.

New Scanners

Graphical readers grew with computers; an experimental SADIE-II was used with the Bureau's Pilot computer, while electronic scanning systems were used at the Bureau in such specialized devices [5,6] as several models of FOSDIC and MAGIC.** The growth of computer speed and memory capabilities made obvious the usefulness of a scanner that would assign digital values to shades of gray in photographs.

This feature was provided by Dr. Moore who, needing a larger device for precision metallographic analyses, designed a gray-reading machine called SADIE-III. It can be used to scan large copy (up to 24 by 24 cm) at a resolution of ¼ millimeter and at each point read the light value on a 64-level gray scale with a certainty of a fraction of a percent. Photographic prints, negatives, or transparencies can be scanned, as well as drawings.

Data from this SADIE, like its predecessor, can be recorded on magnetic tape for input to the computer. The new SADIE has an additional capability; it contains specialized computer circuitry that at the end of the scan displays a partial analysis of the data on two six-digit counters. This feature makes unnecessary the time and cost of a large computer for exploratory work or when only simple results are required.

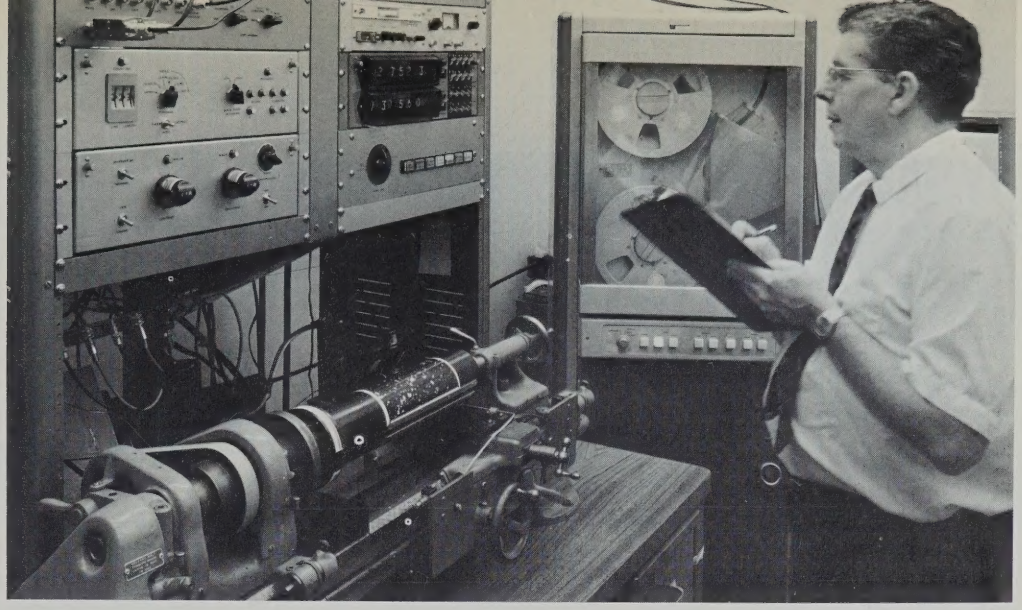
*American Society for Testing and Materials.
**Film Optical Sensing Device for Input to Computers and Machine for Automatic Graphics Interface to a Computer; see references 5 and 6.

Design Features of SADIE-III

SADIE–III was fabricated on a small metric metal-working lathe, an economical source of the dimensional precision and stability required. The micrograph is mounted on a drum turning between faceplate and tailstock. A photomultiplier tube is aimed through a microscope at a point on the drum that is illuminated by two small lens-end bulbs. This optical system is mounted on the lathe carriage and moved across the scan area by the lathe lead screw.

A similar optical system synchronizes the gating circuitry that breaks up each rotational scan into up to 960 sensed positions. Its lights and sensing unit are aimed at a synchronizing strip, attached to the left end of the drum, consisting of alternating black and white bars for most of its circumference and of a black strip for the remainder. The signal from the photomultiplier suppresses sensing when the blanking strip is seen and gates the scan as the black and white bars pass before it.

SADIE's scanning system has built-in correction for some errors inherent in an optical system. The aperture in the scanning system is slightly smaller than the individual scan unit in order to compensate for edge diffraction. Because of the flare effect, some light still enters from outside the scan area, particularly when reading a single black spot sur-



George Moore takes readings from analytical counters on SADIE-III. The 24-cm by 19-cm micrograph on the drum will be examined at 3/4 of a million points and the readings expressed on a 64-level gray scale.

rounded by white. This error is compensated by inclusion as a negative signal of a fraction of the output of three photosensors observing the area around the aperture.

The scanning system also corrects for some defects in the photograph and of illumination. Recently added is circuitry providing a floating gray scale; it remembers successive brightest and darkest points to continuously adjust the proper range of the gray scale. Use of this feature, analogous to the "dodging" and "burning-in" of photographic art, corrects for small systematic differences of illumination in the microscope.

For accurate analysis of area and size, particle edges must be sensed accurately despite the fuzziness characteristic of high-magnification micrographs. Dr. Moore improved edge sensing by designing into SADIE a circuit that adds to the scan signal a time differential obtained from it. When in use this circuit counts doubtful points as the phase being entered. Thus, questionable readings on crossing the boundaries of a particle are scored as the particle on entering and as the surrounding matrix on leaving.

The signal circuitry normally assigns to each point scanned a value on a 64-level scale of equally spaced grays. Also available to the user is a logarithmic density scale that simulates discrimination by the human eye and sometimes differentiates among several phases better than does the linear scale. Either scale can be adjusted to best discriminate among the tones present.

Using SADIE-III

The scanner is used by attaching to its drum the pictorial material—usually a photograph—and setting the controls to match the tone scale and for the analysis desired. Then the lathe carriage is cranked to its leftmost position and engaged with the lead screw to slowly move the sensing system across the rotating drum. The following operations take place automatically: the sensing and analyzing circuits are turned on when the first line to be scanned is reached and off at the last, an "end-of-file" notation is sent following the last datum, and the lathe turns itself off.

SADIE's counter indications are used by the metallurgist to obtain several significant descriptors for the specimen. The area percent of a specific phase is found by dividing the number of counts of that phase's gray value by the total number of points scanned. When the area of several phases must be found the same material is scanned repeatedly by SADIE, with gray levels read by each counter changed on each scan to compile counts of additional phases on its two counters. Effective discrimination sometimes requires the scanning of color transparencies through filters.

Further analysis is obtained from counts of the number of times that the scan enters particles of the phase being studied. The mean size of particles of this tone is obtained by dividing the area count by their intercept number. Division of the matrix area count by the intercept number, on the other hand, gives the mean free path between these particles. These relationships apply to distribution in volume as well as in sections. A size classification unit can be used to indicate the range of particle sizes.

Recent engineering improvements in SADIE's capabilities raised the number of gray levels and added the floating gray scale circuitry, which is necessary to make the increased tone resolution meaningful. These features were particularly desired for metallographic analyses of austenite-ferrite mixtures and of spheroidized carbide structures. Accurately characterized samples of these materials have been needed for use as standards in x-ray phase analysis and in quantitative metallography. Present work with SADIE-III is expected to enable the Bureau to issue new Standard Reference Materials to fill this need.

Although SADIE-III's scanning system was developed for precision metallographic analysis, its procedures are directly applicable to other work—to study of ceramic and biological materials, for example. When more computer capability than offered

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DYNAMIC CALIBRATION OF ACCELEROMETERS

Gravity Supplies Standard

GRAVITY provides the unvarying standard used by an instrument developed by John S. Hilten at the NBS Institute for Applied Technology to calibrate low-frequency accelerometers between 1 and -1 *g*.[1] Operating at speeds between ½ and 45 revolutions per second, the instrument produces values in dynamic calibrations that approach the accurate and highly reproducible values of static calibrations within ±0.1 percent in some cases. The device's precisely sinusoidal movement in the earth's gravitational field has identified resonances and helped disclose limitations in usefulness of some types of accelerometers.*

Calibrating Accelerometers

Accelerometers, vital instruments in the laboratories and equipment of industry and government, are most easily calibrated dynamically by measurement of their electrical output while being vibrated on a "shaker." The accuracy of this method is dependent on a chain of comparisons, however, and may be seriously degraded by a number of sources of error, including the sensitivity of accelerometers to various sideways motions that often accompany the desired linear motion.

In 1966 the Bureau described an extremely simple device for subjecting accelerometers to precisely known components of the earth's gravitational field at zero frequency.[2] This device made possible static calibrations at values between 1 and -1 *g*. Still needed, however, was a means of applying precisely known values of dynamic acceleration to these accelerometers.

New Dynamic Calibrator

Years ago the idea had been advanced of rotating a transducer so that its response could be calibrated against known components of the earth's gravitational field. Mr. Hilten, who had collaborated in developing the earth's field static calibrator, refined the concept into an instrument that applied the field in a sinusoidal pattern to make possible dynamic accelerometer calibrations. The instrument consists essentially of a short horizontal shaft having at one end a vertical flat table and at the other end a slipring assembly and a magnetic coupling to the drive motor. The accelerometer to be calibrated is secured to the table with its inertial mass on the shaft axis and its weight compensated for by positioning of a counterweight.

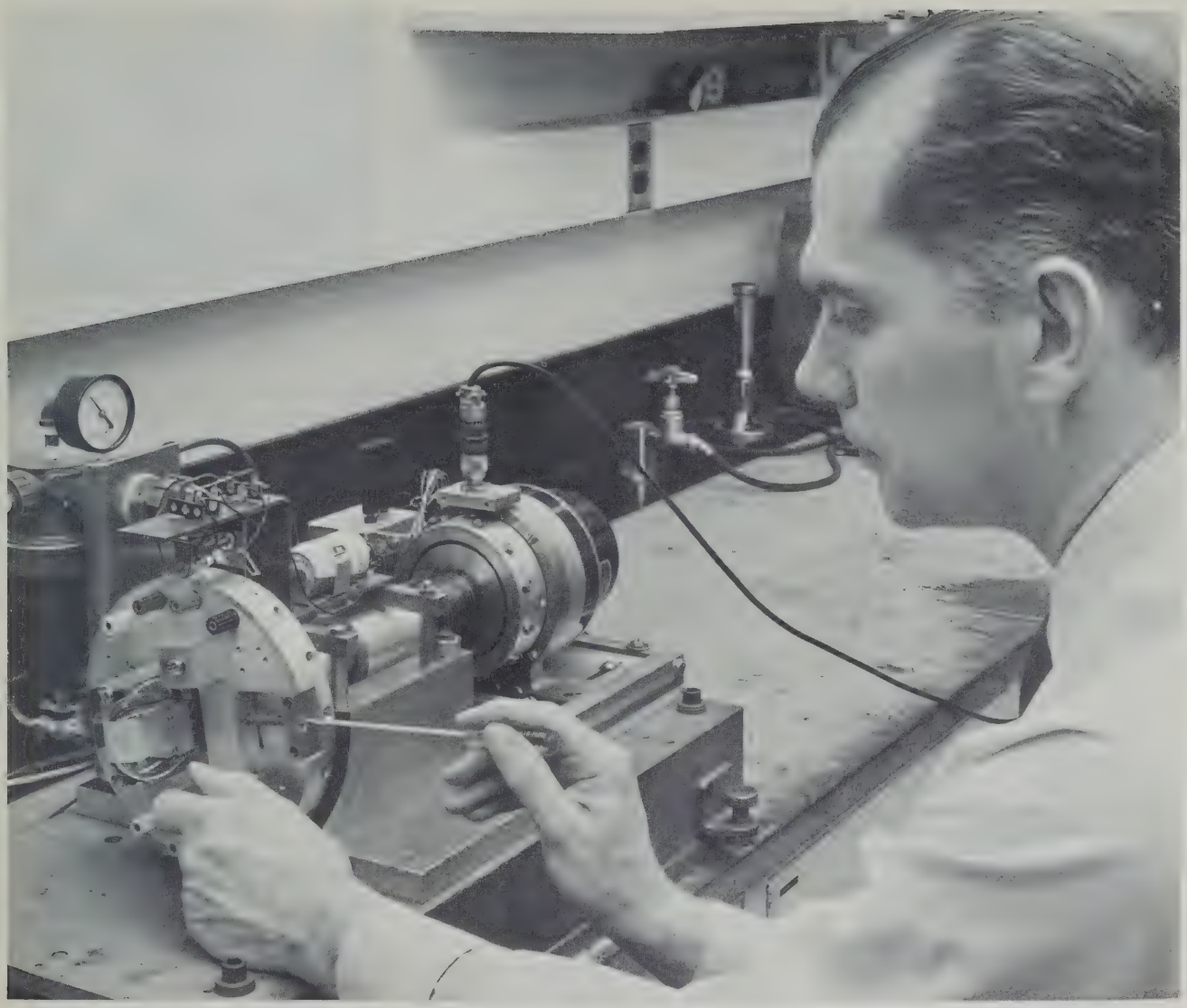
A number of design features contribute to the dynamic calibrator's precise performance: two air bearings alined in a V-block enable the shaft to spin friction-free on air at pressures of 40 psi and above. The rim of the test table has 16 radial holes into which trimming weights can be screwed for balancing. Shaft alinement and noise problems are reduced by a magnetic coupling between motor and shaft; it consists of a disk inside a shallow cup, each with 12 small C-shaped permanent magnets oriented with poles toward the opposing magnets. Finally, the motor is a multiple-pole type, the speed of which can be controlled by a variable dc power supply and is known by monitoring a 2000 pulse-per-revolution signal from a built-in optical tachometer.

Accessory instrumentation includes an electronic counter to read the shaft speed; a voltmeter, recorder, and oscilloscope with a camera to measure and record the accelerometer output; a piezoelectric accelerometer permanently mounted on the table to measure extraneous vibration and help balance the table; and a distortion meter.

Early Findings

The dynamic calibrator was checked out in tests of three servo type accelerometers. The calibrator was first leveled so that the full 1 *g* signal could be obtained. Static calibration readings were taken, then dynamic measurements were made at frequencies from 2 Hz to 24 Hz, and a second set of static readings was taken. The dynamic values were found to be within 0.5 percent of the static value for frequencies from 2–8 Hz, within 0.1 percent for 10–20 Hz, and within 0.2 percent at 22 and 24 Hz. Higher frequencies were not used because the static-dynamic differential fluctuates markedly above the first resonance of

*This work was part of a continuing program of transducer study supported by the U.S. Army, Navy, Air Force, and NASA.



John Hilten positions a counterweight to balance an accelerometer to be dynamically calibrated in the earth's gravitational field.

the calibrator, which occurs at 22 Hz.

It is interesting to note that the dynamic-static differences for all frequencies from 2 to 20 Hz were within the limits of the error of the ac root-mean-square differential voltmeter used, the most accurate of its type obtainable at the time.

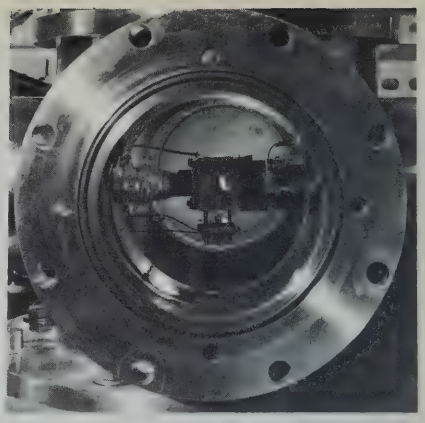
Two more accelerometers of low frequency strain gage types were calibrated at frequencies of 1 Hz and at multiples of 5 Hz up to 45 Hz. Photographic records were made of accelerometer response at these discrete frequencies and also with frequency swept from 45 to 0 Hz by use of a slow sweep, starting exposure at 45 rps, and immediately cutting power to the drive motor. The frequency response characteristic obtained, however, did not fully agree with that obtained by means of a shaker. The difference is believed due to changing centrifugal force acting on the seismic mass when it is displaced due to the motion. Servo type accelerometers are not normally sensitive to such motions.

The new dynamic calibrator is a great improvement over conventional electromagnetic shakers in calibrating precision, high-frequency accelerometers. However, the discrepancies found in the two low-natural-frequency strain-gage accelerometers studied indicate that the new device should be used with such accelerometers only with caution.

[1] Hilten, J. S., **Accelerometer Calibration with the Earth's Field Dynamic Calibrator,** Nat. Bur. Stand. (U.S.), Tech. Note 517 (Mar. 1970).

[2] **Easily made device calibrates accelerometer,** Nat. Bur. Stand. (U.S.), Tech. News Bull. **50,** No. 6, 94-96 (June 1966); and Lederer, P. S., and Hilten, J. S., **Earth's Field Static Calibrator for Accelerometers,** Nat. Bur. Stand. (U.S.), Tech Note 269 (Feb. 1966).

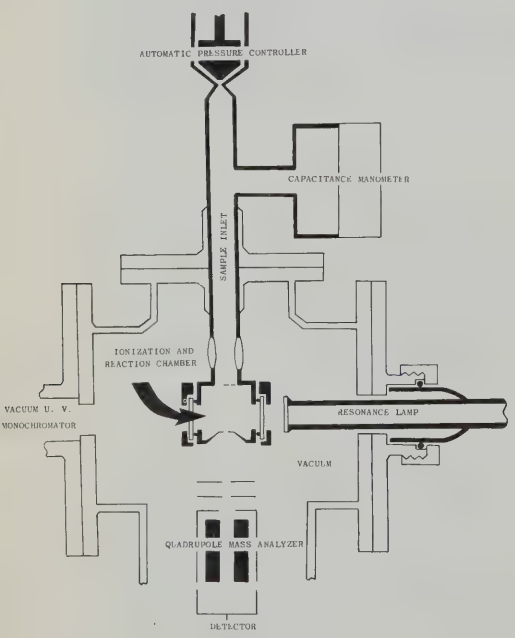
ION-MOLECULE REACTION MASS SPECTROMETER



Ionization and reaction chamber (center) of the new NBS mass spectrometer. Samples being studied enter the chamber (center-left), are photoionized by radiation source (rear), and reaction byproducts are analyzed by the quadrupole mass analyzer (center-right).

A UNIQUE MASS SPECTROMETER has been constructed at the Bureau for investigating reactions of ions with neutral molecules at thermal kinetic energies (room temperature), analogous to conditions encountered in the upper atmosphere and in gas phase radiolysis. This spectrometer has several advantages, including a broad range of operating pressures and a monochromatic source of ionization.

Diagram of new NBS mass spectrometer. Sample gas enters reaction chamber (arrow) through sample inlet, and is photoionized by monochromatic photon radiation from either a resonance lamp (right) or a resonance lamp-monochromator system (left). Ions formed exit through pinhole (bottom of chamber) are accelerated, analyzed, and detected.



The instrument was designed [1,2] by L. Wayne Sieck and P. Ausloos of the NBS Institute for Materials Research, with assistance from Stuart K. Searles, a 1968-1970 NRC–NBS Postdoctoral Research Associate. They received support for the project from the U.S. Atomic Energy Commission.

Perhaps the most important characteristic of this instrument is that the reactant ions are only moving with thermal kinetic energies prior to reaction. The use of the photoionization technique is also attractive, since the maximum internal energy of the reactant ion is always exactly defined. In addition, it is also possible to ionize only a single component in a gaseous mixture by choice of the proper wavelength.

The operation is as follows. High energy photons, produced by a rare-gas resonance lamp,[3] irradiate a sample gas producing positive ions within a chamber in the spectrometer. (These lamps may be combined with a monochromator to allow only the one wavelength desired to reach the spectrometer.) Because there are no internal electric or magnetic fields within the reaction chamber, the photo-ions interact with the sample for time periods restricted only by the ionic diffusion rate of the gas out of the chamber through a small pinhole. After exiting through the pinhole, reactant and synthesis ions are subsequently mass analyzed and detected by a quadrupole filter system. The observed variation of the mass spectrum as a function of chamber pressure leads to the determination of the rate constants for the ionic reactions that have occurred during diffusion. The pressure in the reaction chamber may be maintained at any value from 0.001 to approximately 3 torr.

The instrument has been used mainly to investigate the ionic reactions occurring in alkanes and alkenes.[1,2] Some reactions of inorganic ions with hydrocarbons,[4] as well as the reactions of hydrocarbon ions with inorganic molecules, have also been studied.[5] Many previously unknown reactions have been found in these systems, contributing significantly to the understanding of the mechanisms of high energy radiation damage in both the vapor and condensed phases. For example, the formation of the $(C_2H_6)_2^+$ dimer ion in photoionized ethane has recently been detected.[6]

[1] For further details, see Sieck, L. W., Searles, S. K., and Ausloos, P., **High-pressure photoionization mass spectrometry. I. Unimolecular and bimolecular reactions of $C_4H_8^+$ from cyclobutane**, J. Am. Chem. Soc. **91**, No. 27, 7627–7634 (Dec. 1969).

[2] Sieck, L. W., and Searles, S. K., **High-pressure photoionization mass spectrometry. II. A study of thermal $H^-(H^\circ)$ and $H_2^-(H_2^\circ)$ transfer reactions occurring in alkane-olefin mixtures**, J. Am. Chem. Soc. **92**, No. 10, 2937–2943 (May 1970).

[3] Gorden, R., Jr., Rebbert, R. E., and Ausloos, P., **Rare gas resonance lamps**, Nat. Bur. Stand. (U.S.) Tech. Note 496, 55 pages (Oct. 1969).

[4] Searles, S. K., and Sieck, L. W., **High-pressure photoionization mass spectrometry. III. Reactions of $NO^+(X'\Sigma^+)$ with C_3 through C_7 hydrocarbons at thermal kinetic energies**, J. Chem. Phys. (in press).

[5] Sieck, L. W., and Searles, S. K., **High-pressure photoionization mass spectrometry. IV. Reactions of alkane and cycloalkane molecular ions with water vapor at thermal kinetic energies**, J. Chem. Phys. (in press).

[6] Searles, S. K., Sieck, L. W., and Ausloos, P., **Reactions of $C_2H_6^+$. Formation of the $(C_2H_6)_2^+$ ion**, J. Chem. Phys. (in press).

NBS SURVEYS TIRE USAGE

THE BUREAU has made a thorough review of most of the available data on how automobile tires are used and maintained in this country.[1] The major findings of this study, conducted by J. L. Harvey and F. C. Brenner of the NBS Office of Vehicle Systems Research, and sponsored by the Department of Transportation, are:

- Severely worn tires probably are the cause of many accidents, as a greater percentage of such tires were found on vehicles involved in accidents than in the general tire population.
- Vehicles in accidents have a larger number of severely worn tires on the rear than on the front, suggesting that it is safer to put newer or less worn tires on the rear.
- The risk of tire disablement and loss of vehicle control rises sharply for tires with less than 2/32 in tread depth remaining.
- More than 1 in 4 cars had at least one seriously underinflated tire—by 4 psi or more—and underinflation can lead to early tire failure.
- About 2 percent of cars are overloaded by 10 percent or more, and about 6 percent of cars are somewhat overloaded. On the average, most cars are loaded to about 80 percent of their allowable load.

That tires are an important factor in automotive performance and safety is a fact universally accepted. What tends to be ignored is that how tires are used plays an important part in their safey and performance. Tires cannot—or should not—be installed and forgotten. Regular inspection, and attention to proper inflation, play an important part in determining how long and how well they perform. A concerted educational campaign is needed to alert drivers, service station personnel, and in some cases inspection agencies to those factors contributing to tire life and safety.

Tire Wear—And Safety

Tire tread wears away with usage, the wear rate being a complex function involving a host of variables. Every car owner eventually faces the decision of when a tire is worn badly enough to warrant replacement. Study has shown that the risk of disablement for a tire having only 2/32 in of tread depth remaining is about 10 times that for a new tire. Using 2/32 in of remaining tread as a definition of "baldness," about 12 percent of the passenger cars in service in the Eastern United States had at least one bald tire. When one tire on a car is bald, two out of three times there will be a second. Enough data are on hand linking bald tires to accidents to justify further study and, perhaps, eventual action limiting the use of such tires. As already noted, bald tires on the rear appear to be more of a safety hazard than on the front, a finding at variance with automotive folklore. And bald tires on wet pavement make a particularly hazardous combination.

One saving feature is that most motorists with bald tires know the tires are unsafe at high speeds. Thus, only 2 to 4 percent of bald tires were found in samplings of interstate highway traffic as opposed to the 12 percent of the general population mentioned above.

Inflation

Proper inflation is a major factor in tire life. Particularly detrimental is underinflation, which leads to excessive sidewall flexing, with attendant temperature rise and potential failure. Many studies have revealed a high proportion of underinflated tires, frequently 4 psi or more. Underinflation by as little as 3 psi can significantly reduce tread wear, impair handling, and lead to tire failure. Unfortunately, there is a lack of understanding (or concern) by both the motoring public and service station personnel as to the importance of proper inflation. And even if the concern is there, the equipment for assuring proper pressure is often lacking. A survey of air towers at 50 service stations in the Washington, D.C., area revealed a 45 percent probability that actual inflation will differ by at least 3 psi from the tower setting. While most hand-type pressure gages are more accurate than air towers, many are inaccurate enough to do more harm than good. A mechanism is needed to ensure that gages and air towers are accurate to within 1 psi.

Overloading

Tires are designed to carry a maximum load, and loading beyond this maximum often leads to handling difficulty and premature failure. About 6 percent of the populations surveyed were overloaded. The rear tires of station wagons, and of passenger cars loaded on a vacation trip, are prime candidates for overloading. Some overloading may be due to underinflation. For example, if a tire is overloaded at 24 psi, and 28 psi is within its allowable pressure range, inflating to 28 psi may overcome the

Continued on p. 244

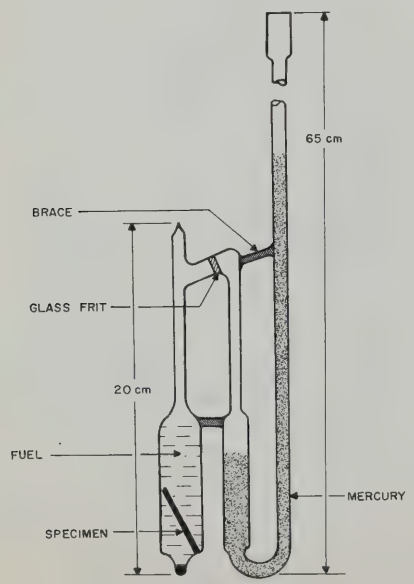
Full-size simulated rocket fuel tank (28 cm in diameter and 36 cm in height). Flanges allow disassembly for inspection after plating; the actual tank is completely welded.

Fuel Compatible Coatings for Rocket Tanks

DURING LONG-TERM STORAGE, ROCKETS containing hydrazine fuels* in maraging steel tanks develop dangerously high levels of pressure. Although maraging steel is a high tensile strength steel that has less weight and bulk per unit strength than many other metals, it is known to catalyze the decomposition of liquid hydrazine fuels. For this reason researchers at the Bureau and the Picatinny Arsenal surveyed the suitability of a number of materials for use as interior surface coatings for the fuel tanks. They found cadmium and electroless nickel to be most practicable in that as plated coatings, they retard the catalytic decomposition of hydrazine and show little corrosion when in contact with it.[1]

*Actually a mixture of hydrazine and monomethylhydrazine.

A representation of the glass, manometer-type units in which specimens were evaluated. The gas evolved from fuel decomposition, caused by the specimen, is measured by reading the change in height of the mercury column.



Thirty-four coatings and materials were tested and evaluated by J. P. Young, V. A. Lamb, G. I. Reid, and J. F. Berkeley of the NBS Institute for Materials Research and W. Ng of the Picatinny Liquid Rocket Propulsion Laboratory. Like the rockets themselves, the coatings must be able to withstand the temperature extremes encountered both in the arctic and in the desert where rockets may be stored up to six years. Because desert temperatures, of the two extremes, would be expected to cause the maximum rate of decomposition of the fuel, most of the specimens were tested at temperatures of 160 °F (71 °C).

The specimens were cut from maraging steel sheet, plated, and tested within glass, manometer-type units. These units have a chamber for holding the fuel and specimen and an attached mercury manometer to measure the gas released by catalytic decomposition. The units were maintained at 160 °F in a constant temperature water bath for as long as three years. During this time the pressure developed by the evolving gas was measured and the volume of gas calculated. The results were taken as a measure of the efficiency of the coating to retard decomposition and were expressed in terms of the pressure developed in a hypothetical "standard" tank, assuming a one-cubic-foot tank with 10 percent unfilled space. In the hypothetical tank the maximum acceptable pressure is 100 psi per year. When calculated from data obtained using the glass test units, pressures generated in the "standard" tank at 160 °F were 2 and 11 psi after one year for cadmium and electroless nickel, respectively, while for unprotected maraging steel, pressure reached 854 psi after the same period of time.

The effectiveness of the specimen in resisting corrosion was evaluated after determining the weight loss of the specimen, the amount of salts dissolved in the hydrazine, and microscopic observation of the surface and cross-section of the specimen. Electroless nickel was found to experience no corrosion and cadmium only a slight, but still insignificant, amount.

Other factors contributed to the favorable evaluation of cadmium and electroless nickel. In addition to being in the low reaction range, cadmium showed the greatest protection of the maraging steel of all the coatings. This was due to the unexpectedly large distance over which cadmium causes a reduction of catalytic gas formation on bare maraging steel. Such a property may be valuable in the protection of the interior surfaces of fuel tanks if the entire surface cannot be completely coated, or if work on the tank subsequent to plating (such as welding) should damage areas of the coating.

The second material, electroless nickel, offered the greatest ease of application. Because it is applied without use of electrodes or current, it is a likely coating for the interior surfaces of assembled tanks. The coating also is very uniform, especially in fuel tanks with recessed surfaces or of complex design.

The researchers have also applied these two coatings to half-size and full-size simulated rocket tanks for further testing under conditions approximating those encountered by actual rockets in storage.

[1] Young, J. P., Lamb, V. A., Reid, G. I., Berkeley, J. F., and Ng, W., Electroplated coatings on maraging steel for retarding catalytic decomposition of hydrazine rocket fuel, Plating 57, No. 9, 921-926 (Sept. 1970).

Improved Drive For Soft X-Ray Spectrometer

JOHN R. CUTHILL of the NBS Institute for Materials Research has developed a detector drive for a grazing incidence concave grating spectrometer that provides constant resolution over the spectrum.[1] This drive is incorporated in the soft x-ray spectrometer used in the Institute's metallurgy laboratories. The drive's advantages stem from the fact that the lead screw, which moves the detector carriage along its curved track, also aims the detector at the grating, keeping the effective detector slit constant in width for all wavelength settings. This arrangement keeps the spectrometer's resolution constant for all wavelengths; the increased rigidity of this design also contributes to improve resolution.

Soft X-Ray Spectrometers

Soft x-ray spectroscopy employing a grazing incidence grating spectrometer has many applications.[2] X-ray spectrographic analysis for the light elements is important to metallurgists and chemists. Also, soft x-ray spectroscopy is one of the few techniques for getting information on the density of electron energy states throughout the width of the valence band.[3] The same type of spectrometer also is carried in satellites to send back spectral information on the sun's radiation in the soft x-ray region. These instruments are usually designed by the user and are custom-made by or for him.

The instrument used at the Bureau is a grazing incidence emission spectrometer that was designed by Dr. Cuthill. It has an electron gun to bombard the specimen, which emits soft x radiation that impinges on a ruled glass grating. The spectrum resulting is sensed by a detector that is mechanically moved along a curved path traversing the spectrum. As it moves the detector must look squarely at the grating and its slit plane must be normal to the beam path in order for instrument resolution to remain constant. The difficulty of designing this instrument is increased by the fact that most of its components operate in vacuums in the 10^{-7} torr to 10^{-8} torr range (10^{-5} to 10^{-6} newtons per square meter).

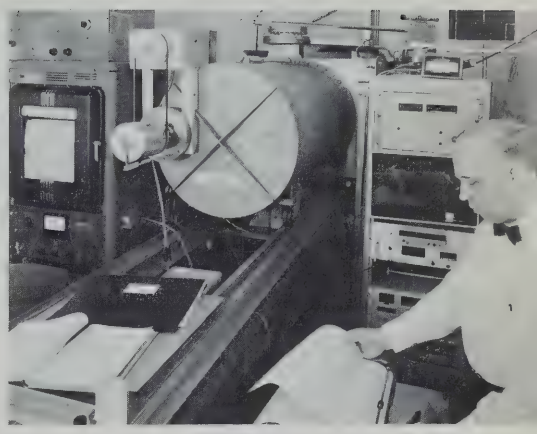
NBS Spectrometer System

Dr. Cuthill improved on other spectrometers by driving his detector carriage along its arc by means of a lead screw that is pivoted directly under the grating. The detector is firmly attached to the lead screw by a split nut that also aims the detector and its slit at the grating. The 1-mm-pitch lead screw is turned at its pivoted end by a bevel gear, which is engaged by a double-faced bevel gear driven by another bevel gear on a drive shaft. The other end of this shaft is driven by a magnetic clutch that bridges the vacuum barrier. The clutch is turned by a stepping motor that is energized to turn at 3 rpm by a 10-pps signal. The detector is permanently enclosed within the vacuum system, but its position is known from a mechanical counter on the outside clutch shaft.

The counts picked up by the photomultiplier detector are integrated and recorded every 4 seconds. They are printed as numerals and also recorded on magnetic tape for later computer processing. For monitoring purposes the system also records an analog plot on a stripchart recorder.

Electronic circuitry for the system includes a preamplifier mounted in the vacuum on the detector, an external pulse amplifier, the counter that is also the source of motor drive pulses, and a translator for the pulses to the motor.

The next generation of the NBS soft x-ray spectrometer is already under design; it is an absorption type instrument for use with light from the Bureau's synchrotron.[4] It will feature a drive motor contained within the vacuum chamber.



A digital printout of an emission spectrum from the x-ray spectrometer is examined by its designer, John Cuthill. All optical and some mechanical components of the spectrometer are in the large cylinder (center). Data are recorded on a stripchart (left), on paper (foreground), and on magnetic tape (right) for input to a computer.

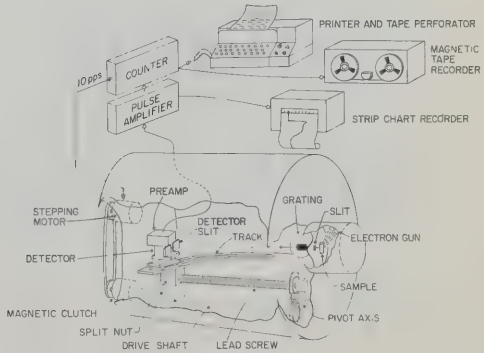
[1] Cuthill, J. R., **A soft x-ray spectrometer with improved drive**, Rev. Sci. Instr. **41**, 422–423 (Mar. 1970).

[2] Cuthill, J. R., **Soft x-ray spectroscopy**, Encyclopaedic Dictionary of Physics, Suppl. Vol. 4, Pergamon Press (1970).

[3] Cuthill, J. R., McAlister, A. J., Williams, M. L., and Watson, R. E., **Density of states of Ni: Soft x-ray spectrum and comparison with photoemission and ion neutralization studies**, Phys. Rev. **164**, 1006 (1967).

[4] **NBS installs synchrotron at Gaithersburg laboratories**, Nat. Bur. Stand. (U.S.), Tech. News Bull. **53**, 4–5 (Jan. 1969).

The relationship among optical, electrical, and mechanical components of grazing incidence grating spectrometer. The lead-screw drive that advances the detector keeps the slit aimed at the grating, resulting in this spectrometer's improved resolution.



Operators sorting mail on a typical Letter Sorting Machine at the rate of 60 letters a minute. They read the address and punch a 3-digit code on the keyboard, which directs the letter into 1 of 277 bins.

NBS RESEARCHING HUMAN ASPECTS OF MOVING MAIL

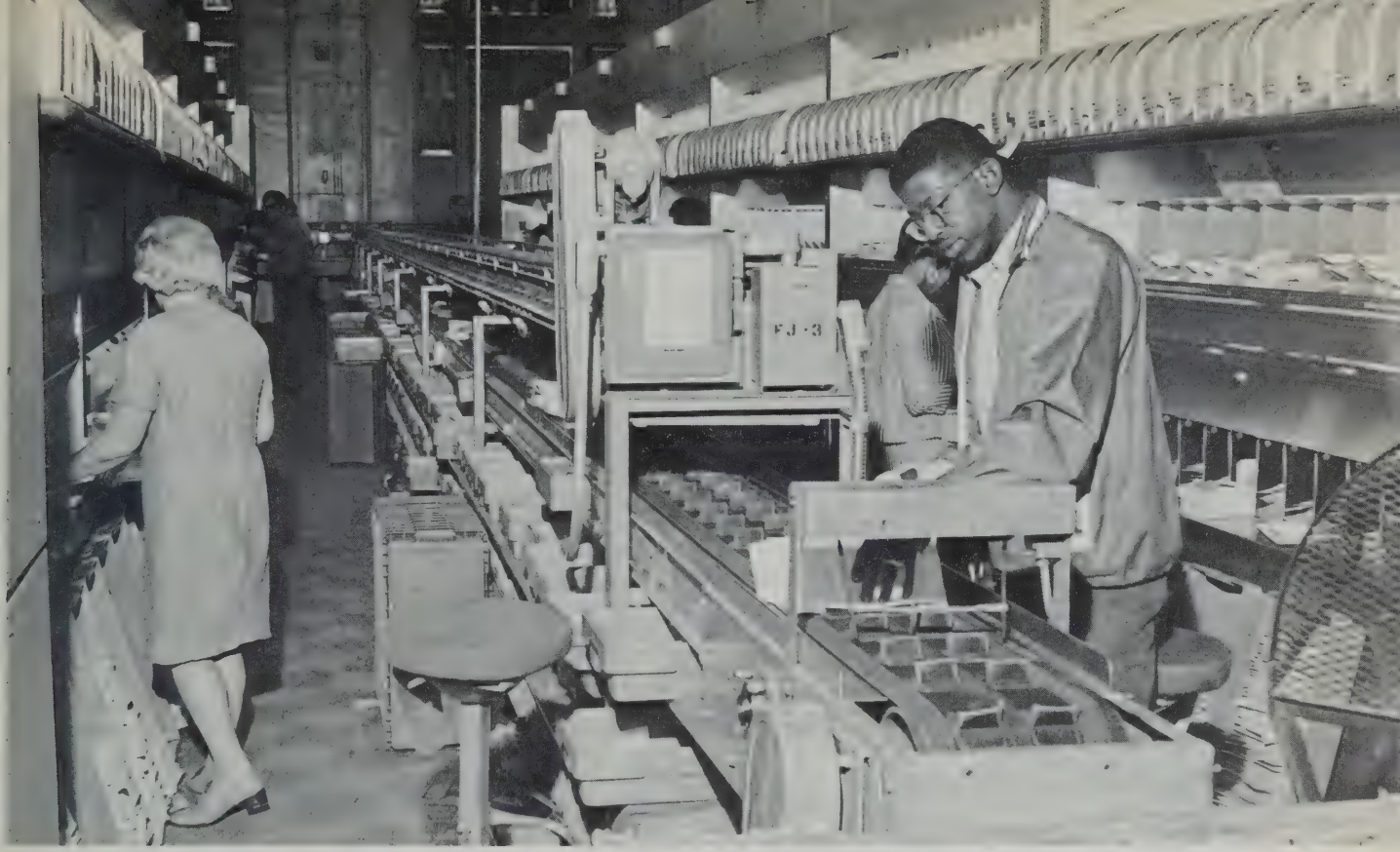
THE BUREAU, under sponsorship of the Post Office Department, is investigating the human aspects of moving the mail.[1] The goal of this research is enhanced productivity by suiting the environment to the man, thus making the process of production agreeable and psychologically stimulating to the worker. It is becoming apparent that in a man/machine operation, as much or more consideration must be given to the person as the machine.

The Post Office Department is an organization that combines the services required of a Government agency with the operations typical of a gigantic materials-handling industry. It requires both machine and human operations and, with steadily increasing amounts of mail to be handled, is constantly seeking increased efficiency. Through the Post Office's Bureau of Research and Engineering, a Human Factors Laboratory staffed by NBS personnel under supervision of Dr. June Cornog, is helping to solve some of the more critical problems of moving the mail.

Letter Sorting Machines

One area of study involves operators of letter sorting machines (LSM). The LSM's are 77½ feet long, 9½ feet high, and 12 feet wide, with 12 operator consoles attached. In operation of the LSM, letters are transported at the rate of 60 per minute in front of an operator who reads the address and then keys a 3-digit numeric code into the machine's memory. With this number the LSM is instructed to place the letter in one of 277 receptacles arrayed across the back of the machine. The bins are "swept" or cleared manually and letters are bundled or trayed before being moved to other areas for sacking.

The entire operation of a typical LSM depends on an operator's correct application of the 3-digit number. A specific number is assigned to all possible geographic locations and operators commit the number-



Mail sorted with a Letter Sorting Machine is placed into one of these 277 bins, which are cleared manually.

geographic location pair to memory. For letter sorting, the operator has about ⅛ second to recall the correct number after reading the address and another ¼ second to enter it into the keyboard.

The LSM has only 277 sorting bins, with a consequent limitation of 277 numeric codes. Therefore, each number is used for many locations. In addition to the outgoing mail, a sort scheme for a large city may contain up to 4500 different distribution scheme items, each of which also is equated to one of the 277 separation bins. This constitutes a considerable memory task for the operator. All LSM operators are supposed to have nearly perfect, instantaneous recall for both city and outgoing sort schemes.

Under the usual schedule, operators work 45 minutes at the keyboard, and then 15 minutes on an alternate task before returning to the keyboard for another 45 minutes. During the Christmas rush in Miami, Fla., in 1968, operators were permitted to work 30 minutes at the keyboard, followed by 15 minutes for alternate activity before returning to the keyboard. An 11-hr workday was considered justification for the shorter cycle. When the rush was over, the original schedule was reinstated. The operators, however, greatly preferred the 30/15 schedule and requested that it remain in effect. They felt that errors were reduced because of less fatigue, fewer lapses in attention, and the lower effort required to keep themselves alert while continuing to code 60 pieces of mail per minute. This experience and observations in other cities brought about a request to the BRE Human Factors Laboratory staff to conduct a reliable study of actual coding performance in operating field offices to ascertain the measurable differences in output and accuracy under the two schedules.

The resulting study was carried out in the Memphis, Tenn., Post Office. The study consisted of taking samples of regular production at unannounced times during the day, over a period of twenty work days (one calendar month) for the 45/15 cycle. Following this phase, the work-rest cycle was changed to the 30/15 cycle, and operators were given two weeks in which to adjust to the change. A second sampling phase was then carried out for another twenty days. Productivity and error rates for the two experimental situations were compared both for the group and individual operator performance. Analysis of the data indicated the shorter work period was significantly better. For a given period of time operators sorted more mail on the 30/15 work rotation cycle than on 45/15 and reduced their error rate to ½ that of the longer cycle.

Pace of Work

At the present time, all letter sorting machines in the U.S. Post Office present letter mail to operators at a set rate of speed, a process called machine pacing. According to the type

of mail to be processed, the machine may be set to "singulate" and deliver envelopes to the viewing field of the operator at 55, 60, or 65 pieces a minute. High production rates can be achieved with this system.

The present system has some problem areas, however, in that it depends on the memory of the operator to produce unerringly in a fraction of a second the right 3-digit code for the address presented, and then to enter the code in the "memory." In addition, the constant, regular passing of envelopes in front of the eyes of the operator seems to have a semimesmeric effect and the operator frequently begins to fight sleepiness after the first few hours of work. Machine pacing of work also tends to make the operator miskey a code or key a wrong one rather than miss the envelope entirely, if his memory slips for a second.

Synchronously operating LSM's are much the easiest to design so the U.S. Post Office has preferred historically to make men conform to machines. The advantages of having operators work at their own pace, however, are so numerous that ways are now being sought to render asynchronous operator input compatible with an internally synchronous sorting machine. When they are able to work at their own speeds, operators can key any length codes, can sort to any number of bins inside the machine, tend to have fewer errors because they can hesitate when they don't have instant recall for a code, work under less tension so they are less tired and make fewer errors, and can begin work at the sorting console with a shorter training period. With all these advantages, just one question remains—can and will clerks be as productive working at their own speeds as they are when the machine sets the rate?

The HFL was asked to conduct a study to determine whether machine or self-pacing was really superior when the two were compared under relatively controlled conditions. Two kinds of keyboards, with both self- and machine-pacing being used on each, were set up for an evaluation study. Results of the study so far have shown that self-paced operators are superior to the machine-paced operators on speed and have a far lower error rate.

Reading Rates

Systematic information on human vision as it is used in postal sorting tasks is not presently available. When postal clerks look at the address on an envelope, how fast are they able to read it? Can they pick out parts of the address without having to read it all? How rapidly can they pick out certain letters within the body of a name? Do they see Zip Code numbers better when the digits are grouped or ungrouped? Are certain commonly used type fonts more rapidly legible than others? These and many other questions will be studied in the course of human factors experiments with a Tachistoscope. With this instrument, visual material can be exposed for very brief periods of time and reading rates or time to locate a particular part of the address can be exactly measured. When reading or recognition rates have been established for a good-sized sample of postal clerks, letter mail processing rates can be established on a firm basis; methods for encoding or abbreviating addresses can then be based on a good estimate of human ability to use the method quickly and accurately.

Remote Viewing

Other human factors studies are in progress either by the Human Factors Laboratory or under contract. In one, the feasibility of using closed circuit television for mail viewing by the LSM operator is being studied. This concept allows operators to be removed from the operating floor of a Post Office with a reduction in the noise, dust, and heat to which they are normally subjected. Another study deals with the possibility of coding the mail from voice commands instead of instruction by the keyboard. Computer-type equipment would accept spoken numerals and translate them into electronic instructions. A commercial translator has been developed that can correctly identify numerals for 90 percent of the digits spoken into it. Again, human capabilities play a role, and an investigation is underway by the Human Factors Laboratory to determine how long a person can do this kind of talking and how many digits a minute he can pronuonce comfortably. Results of the study so far have shown that voices can stand the task provided the subjects are in good health, are not overly tired generally, and do not have to pronuonce more than about 40 two-digit codes a minute. One of the subjects, a smoker, did develop roughness of the voice.

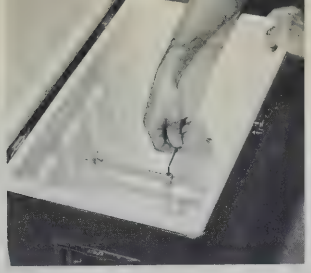
The Human Factors Future

Future investigative work in the HFL will include experimental studies on such areas as: new keyboards and compatible coding systems; further work on error rates in sorting the mail; better techniques for doing various kinds of work; ways to improve the safety of equipment and mail handling methods; lighting of the work-place and the advantages of permitting the operator to control his own light level; seating and other kinds of physical support; the manual sorter's task and methods for improving it; and new training equipment for new types of jobs.

The human factors program plans to provide both immediate and long-range support to Post Office equipment and systems designers, training personnel, and operating groups. Future and longer-range research will form a program that reaches all aspects of people working in postal operations: the man himself, his machine and working methods, his working environment, his morale, and his training.

[1] Cornog, D. Y., and Cornog, J. R., Human Factors Engineering in the Sorting and Handling of Mail, presented at the NATO Advanced Study Institute, Mondello, Sicily, Sept. 29, 1969.

NBS and Industry Seek to Eliminate "Killer Coolers"



Bar divider inserted in a picnic cooler reduces the continuous space of the cooler and eliminates the danger of a child becoming accidently locked inside.

An NBS investigation recently uncovered 16 cases of accidental deaths by entrapment of children in portable picnic coolers. The study was being conducted to determine the effectiveness of the mandatory standard issued pursuant to the Safety Devices for Household Refrigerators Act of 1957. The Bureau and the Department of Commerce are now in the process of making the public aware of this new and potentially serious hazard brought about by the increased popularity of portable picnic coolers. At the same time, the Bureau is working with the manufacturers of coolers to see that dangerous cooler designs are modified or replaced entirely to eliminate the hazards from next year's production of picnic coolers.

Picnic coolers present a problem because they are designed to be relatively air-tight and have good insulation characteristics so that they might hold food and drink at low temperatures. These same characteristics may mean death for an entrapped child, however, because once locked in, his air supply is cut off and his cries for help are muffled. He can do little but wait for death.

The danger of entrapment is heightened significantly if picnic coolers have latches that lock automatically. The majority of the 16 cases studied by the Bureau involved picnic coolers that had self-locking lids. The reports made available to the Bureau indicated that children ranging in age from 1½ to 6 years old had died in picnic coolers. One of the coolers with dimensions as small as 10 inches wide by 20 inches long by 12 inches deep (about 1.5 cubic feet) was involved in these deaths.

Concerned with the reports of the deaths of these small children, the Bureau called a meeting of all known portable picnic cooler manufacturers in Chicago to discuss the problem and to work out a solution that would be practical and acceptable to all concerned. At a subsequent meeting held in Washington, industry representatives suggested that the Department call public attention to the potential danger of entrapment of children in the coolers prior to the summer picnic and camping season. In response, a 30-second film was prepared and subsequently distributed to many TV stations around the country to be shown as a public service announcement. A major press conference also was held at which Secretary of Commerce Maurice Stans and Virginia Knauer, Special Assistant to the President on Consumer Affairs, stressed the potential danger of picnic coolers. The producers also decided to use the Voluntary Product Standards procedures of the Department of Commerce to develop a performance standard which, if accepted by all of the two dozen U.S. firms now manufacturing picnic coolers, would eliminate the hazards from coolers made in the future.

At the second meeting Bureau personnel demonstrated possible design changes and outlined performance requirements for closures of portable picnic coolers. After the Bureau's presentation, the industry representatives present at the meeting agreed to establish a technical committee to assist in the development of performance criteria for coolers, which could be incorporated into a standard.

Industry engineers and Bureau technical personnel are now investigating designs and materials that will accomplish either of two alternatives: *Keep the children out, or guarantee their escape from picnic coolers they venture into.*

An important decision reached at the second meeting was to eliminate the production of picnic coolers with self-locking mechanisms. Immediately after that meeting the Bureau's Office of Engineering Standards Services developed a proposed standard that would require the installation of releasing devices in coolers that are locked manually from the outside. These devices would enable children to get out when "accidentally" locked in by playmates. Internal release devices for coolers with friction-held lids were not required in the proposed standard, but a performance test to require all lids or escape devices to be openable with a force of 10 pounds or less was included in the proposed standard.

Even with the present top-priority program underway, newly designed picnic coolers would not appear on the market before 1971. There are a few relatively simple precautions, however, that a picnic cooler owner can take to eliminate the potential hazard of existing coolers, particularly the self-locking types. Lids or tops of picnic coolers, after each use, could be removed by pulling the hinge pins or unscrewing the hinges. If the latch is screwed on, it could also be removed. If the cooler is equipped with bail type handles, these too might be removed. If the lid or cover cannot be removed a cinder block or similar heavy object could be placed in the bottom of the cooler to effectively reduce the space while it is being stored. Another solution, a more permanent one, would be to attach a bar divider to the cooler wall to reduce the cooler's continuous volume so that a child could not crawl inside it. Information on the availability of the bar and instructions for inserting the bar in a picnic cooler can be obtained from the Office of Engineering Standards Services, National Bureau of Standards, Washington, D.C. 20234.

NOTES

MAGNETIC MEDIA STANDARDS AND MEASUREMENTS

The representation of data in a machine usable form using magnetic recording media is a common practice in today's world of advanced technology. The ordinary office electric typewriter can be outfitted with a magnetic recording device. This simple application of a magnetic recording technique provides for more quality production from the typist by allowing for playback and modification of typed material. Also, the office typewriter can be used to generate data for input to electronic computers and to transmit and receive data from remote locations. This basic example reflects the increasing use of magnetic recording technology.

Magnetic recording is a method of recording data by impressing a pattern of magnetization on a thin layer of magnetic material. The magnetic material is often carried by a nonmagnetic base in the form of a disk, drum, wire, or tape. Several different methods for recording data are employed, but generally the presence, absence, or degree of magnetism is used as the basis for machine detection, logic, and processing.

The use of magnetic recording media within the Federal Government and industry has increased phenomenally in recent years. In excess of one million reels of one-half-inch magnetic computer tapes are procured annually for use by Federal departments and agencies. These tapes are used to store historical data in the National Archives as well as being used in current data processing applications. Tapes are used to transfer data from one installation to another. Vital economic statistics are made available in tape form for use by industry and government.

In recognizing the need for basic standards and measurement techniques for magnetically recorded data, the NBS Center for Computer Sciences and Technology has undertaken several major projects to assist industry and government to better procure and utilize this essential resource.

The NBS program is currently directed toward two major goals:

1. To develop standards for the recording of data on magnetic computer tapes, disks, and similar media, and

2. To develop basic measurement techniques and systems for evaluating these media in both recorded and unrecorded forms.

To date, the program has resulted in the following:

1. Three magnetic tape standards for recording data on one-half-inch, 9-track computer tape have been developed. These standards provide for recording data at three different recording densities of 200, 800, and 1600 characters per inch (CPI). The 800 CPI standard has been approved as a Federal Information Processing Standard (FIPS 3). All magnetic tape drives operating at this density procured by the Federal Government must be capable of conforming to this standard. The 200 CPI tape standard is designed for use in low performance tape and related read/record equipment; the 1600 CPI tape standard is for use in more costly, high-performance equipment and applications. Both are currently being processed as proposed Federal Information Processing Standards. Each of these standards prescribes the format for recording the American Standard Code for Information Interchange (ASCII), the location of the recorded images, and the acceptable levels of the recording. Also, test methods and measurement techniques are provided for evaluating performance requirements in relationship to established reference standards and measurement systems. In the development of these standards, NBS has participated actively with other experts from industry and government through the activities of ANSI Sectional Committee X3, Computers and Information Processing. In addition to being considered as Federal Standards, these have been or are currently being processed as American National Standards. Internationally these are also being processed as standards through the activities of the International Organization for Standardization.

2. A proposed unrecorded magnetic tape standard for one-half-inch digital recording has been produced through cooperative efforts with ANSI. This specification is directed toward the characteristics of the physical and magnetic tape media and the reels around which the tape is wound. Test methods are provided where these are considered necessary. This proposed standard is currently being processed both as a Federal Information Processing Standard and as an American National Standard.

3. A measurement system for

evaluating the signal amplitude of one-half-inch computer tape has been developed and implemented. The principal objective of the measurement system is to provide a quantitative basis by which tape performance and equipment characteristics can be measured and stated in terms of a common test method and measurement technique. This measurement system is used as a basis for the specification of basic tape-recorded standards mentioned in items 1 and 2.

4. A signal amplitude reference tape has been developed for use in the calibration of computer tape recording and reproduction equipment. The reference tape serves as a common point of measurement for use by industry and government in that a tape manufacturer can maintain production controls by comparing the characteristics of manufactured tapes to the reference tape. Tape testing laboratories that have the task of qualifying and accepting tapes through procurement also have a common yardstick for making evaluations. Also the ADP installation manager who specifies these standards in the acquisition of equipment and tapes can expect better performance in his processing and interchange of data.

The evaluation and testing of computer tapes that are to be procured by the Federal Government is the responsibility of the GSA Magnetic Surfaces Laboratory (MSL). The NBS Magnetic Media Measurements Section has provided MSL with a new signal amplitude measurement system developed by Sidney Geller.[1] An equivalent system is also used at NBS for calibrating the computer amplitude reference tapes, NBS Standard Reference Material 3200, that are being supplied to the magnetic tape and equipment industries both nationally and internationally.[2] In addition, the new measurement system is used for producing the primary and secondary reference tape groups and in providing measurement services to private industry.

Future Standards—Disk and Tape Cassettes

The application of digital magnetic recording and reading techniques is being extended to various types of disk and tape storage media. Many of the third generation systems are configured only with disk-oriented hardware and supporting software systems. Removable disk packs, which have higher speeds and random-access capabilities, are being used increasingly as primary auxiliary storage on data processing systems. Indications are that the amount spent for the acquisition of disk packs will surpass that for magnetic computer tape within the current year.

Various forms and sizes of tape cassettes are being developed and implemented to provide for the data capturing and storage of machine readable information. The application of small computers that need equally comparable input/output storage media, and the increased use of remote terminals have expanded the needs for comparatively less expensive data capturing and auxiliary storage media.

With the increasing use of disk packs and tape cassettes, the development and establishment of technical standards and standards of measurement is essential to ensure that these products are interchangeable among the different data recording and reproducing equipments. Recognizing the important role of disk packs and tape cassettes in various fields of application, voluntary standardization efforts have been undertaken within ANSI Committee X3. NBS has undertaken a program to support the disk standards activities. This program includes the establishment of a national reference disk and development of measurement techniques for evaluating the various amplitude related performance requirements. The Center's efforts in this area would be very similar to magnetic tape efforts previously discussed.

[1] NBS instrumentation aids GSA Magnetic Surfaces Lab, Nat. Bur. Stand. (U.S.), Tech. News Bull. 54, No. 10, 237–238 (Oct. 1970).

[2] Available from the Office of Standard Reference Materials, Room B308, Chemistry Building, National Bureau of Standards, Washington, D.C. 20234, for $695.

NBS INSTRUMENTATION AIDS GSA MAGNETIC SURFACES LAB

The NBS Center for Computer Sciences and Technology has provided the General Services Administration (GSA) with a new signal amplitude measuring and recording system for testing magnetic computer tape.[1] The system, a redesign of an earlier NBS signal amplitude measuring system, is extremely rapid, recording side-by-side on a stripchart the signal peaks and their averages for three channels

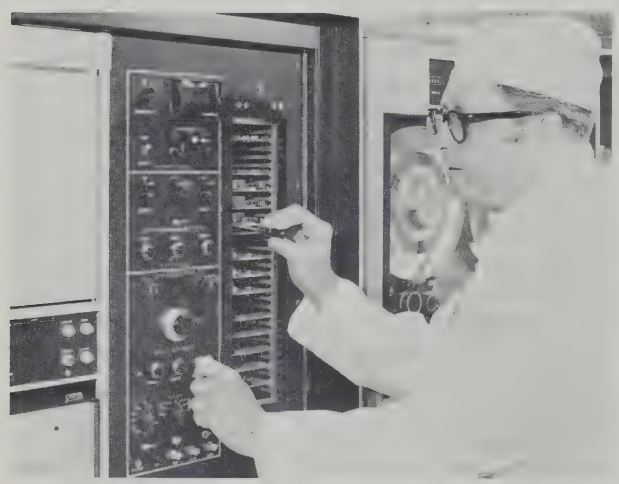
of a 2400-foot tape in less than 5 minutes. The GSA Magnetic Surfaces Lab, now located at the Bureau's Gaithersburg, Md., site, is using the new system in the qualification and acceptance testing program for procuring computer tape for the Government, the largest user of electronic data processing in the world.

GSA Magnetic Surface Testing

The Magnetic Surfaces Laboratory was established to insure that the Government selects wisely in buying magnetic tape, disks, and drums for recording computer, instrumentation, audio, and video data. Two years ago the Laboratory moved to the facilities of the National Bureau of Standards where it would benefit from proximity to the Bureau's research on magnetic media. The new facility was planned by H. A. Abersfeller, Commissioner of the Federal Supply Service, and G. W. Ritter, Assistant Commissioner for Standards and Quality Control, and is directed by A. J. Burkhart, Jr.

The Magnetic Surfaces Laboratory supports GSA's procurement program by testing samples of material from vendors wishing to be placed on GSA's Qualified Products List and performing acceptance testing on samples from deliveries. The data gathered in such testing is also of use in preparing and refining the related procurement specifications.

Most of the Laboratory's work is on magnetic tape, increasing quantities of which are required for operation of the Government's computers and for archival storage of data. Tape characteristics tested include playback amplitude, the presence of dropouts and dropins (loss or addition of data bits due to nonuniformity or imperfections of the magnetic surface), abrasiveness to tape transport heads, separation of tape particles, longitudinal curvature, skewing, and resistance to "cupping" and physical degradation when subjected to heat and humidity. In order to measure recorded signal amplitudes the GSA Laboratory asked the Bureau to supply a new version of the NBS tape test system.



Sidney Geller adjusts the circuitry of the magnetic tape playback amplitude analyzer he designed. All engineering adjustments and circuit cards are accessible at the console's front panel.

New Pulse Amplitude Instrumentation

NBS engineers Sidney B. Geller and Paul A. Mantek, in association with IBM Research Associate Norman Cleveland, had developed the first system for accurately measuring the amplitudes of signals read from a standardized recording on magnetic tape using circuitry for averaging the pulse peak amplitudes.[1] This system was used by NBS in selecting the tapes held in repository as primary and secondary unrecorded amplitude reference standards, to develop a magnetic tape Standard Reference Material,[2] and to measure and certify the samples used internationally to calibrate working reference tapes.

A new tape test system—Process A-Model 2—developed for GSA by Mr. Geller and fabricated by Amory Ericson, was designed to be compatible with the equipment already in use at the Magnetic Surfaces Lab and to be easily used by technicians. Circuitry was designed so that routine calibration of the system could be performed by the technician using it; the panel contains all of the meters and the console sources for all of the test voltages needed for calibration and most trouble-shooting. All indicators and controls are on the front panel, with the operator's controls clustered for greatest accessibility.

Model 2 includes new signal-dividing networks and peak detect-sample-and-hold circuits, permitting rapid changes in operating frequency. The system can monitor its own performance by means of circuitry detecting changes in the master head and tape read signal amplitude. Easy maintenance of the system is further facilitated by giving access to the circuit cards from the front panel.

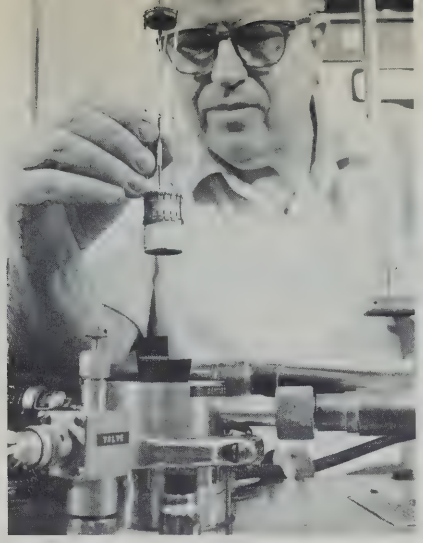
The measuring system output is recorded in two forms. A stripchart recording shows the signal peaks and their average from the read heads for tracks 2, 5, and 8 of a 9-track record. An *x-y* plotter also built into the console shows the curve of read-head output voltage as a function of write-head drive current.

The new instrumentation can be used to evaluate tape on which data are packed at an 800-character-per-inch density or at a 3200-flux-change-per-inch density. Its speed, simplicity, and production of a permanent record make the new signal amplitude system especially useful for continuous testing of large volumes of tape.

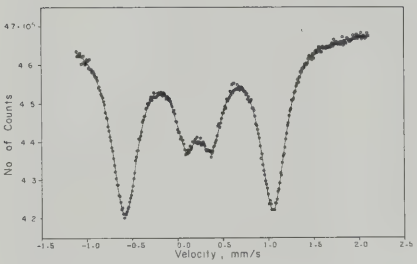
[1] Averaging the peak amplitudes of pulses: Instrumentation for evaluating magnetic tape, Nat. Bur. Stand. (U.S.), Tech. News Bull. **53**, 224–225 (Oct. 1969) and Geller, S. B., Mantek, P. A., and Cleveland, N. G., Standard Reference Materials: Calibration of NBS Secondary Standard Magnetic Tape (Computer Amplitude Reference) Using the Reference Tape Amplitude Measurement "Process A", Nat. Bur. Stand. (U.S.), Spec. Publ. 260-18, 41 pages (Nov. 1969).

[2] Information Processing Notes: New reference tape standard, Nat. Bur. Stand. (U.S.), Tech. News Bull. **53**, 118 (May 1969).

Mössbauer Spectrometer Calibration Using TiFe



R. D. Robbins of the Alloy Physics Section lowers a Mössbauer sample into a superconducting magnet system.



Typical spectrum of TiFe in a 50 kG magnetic field. In the new NBS method of calibrating Mössbauer spectrometers, determination of the splitting of the outer doublet calibrates the spectrometer directly in magnetic field units.

THE MÖSSBAUER EFFECT has become a useful spectroscopic method for metallurgical and chemical analysis, for studying the magnetic properties of materials, and for studying the properties of atomic nuclei. In all such applications the Mössbauer spectrometer must be accurately calibrated, usually by a direct determination of the velocity of either the emitter or absorber. L. J. Swartzendruber and L. H. Bennett of the NBS Institute for Materials Research have developed [1] a new velocity-independent method of calibrating the spectrometer directly in terms of magnetic field units. This method is based on their recent discovery of the ^{57}Fe nuclear magnetic resonance in non-ferromagnetic TiFe.

The new method depends on knowing the magnetic field at the ^{57}Fe nucleus. Previously this magnetic field could not be determined because when a known magnetic field is applied to a material containing ^{57}Fe nuclei, the atomic electrons are acted upon by the applied field and present a different field to the ^{57}Fe nucleus. This difference between the applied magnetic field and the field at the nucleus—known as the Knight shift or chemical shift—recently was successfully measured [2] by the NBS investigators with the assistance of J. C. Swartz, an NBS Research Associate from the U.S. Steel Corp. Their accurate determination of the ^{57}Fe Knight shift in TiFe permits the determination of the magnetic field at the ^{57}Fe nucleus when a known magnetic field is applied. Thus direct calibration of a Mössbauer spectrometer in magnetic field units is possible. Also favorable in permitting this measurement is the structure of TiFe; that is, each iron atom is in a cubic site, precluding distortions due to the ^{57}Fe quadrupole moment.

The new NBS method consists of calibrating the spectrometer from the splitting of the ^{57}Fe spectrum in TiFe in a known external magnetic field. The applied magnetic field acts upon the energy levels of the ^{57}Fe nucleus, splitting the otherwise single spectral line. From the separation of the resulting lines the spectrometer can be calibrated in magnetic field units. These units then can be converted to velocity units, making use of the wavelength of the Mössbauer effect gamma ray, already accurately determined by x-ray diffraction.[3] By varying the applied magnetic field, a wide range of velocity calibrations is possible. In addition, the linearity of the spectrometer can be checked over a wide range.

Comparison of the velocity-independent method with velocity-dependent methods—e.g., laser interferometry and the mechanical screw method—was obtained by a calibration for the quadrupole split lines of the standard Mössbauer absorber, sodium nitroprusside (NBS Standard Reference Material 725, $Na_2[Fe(CN)_5NO]\cdot 2H_2O$). Using the Mössbauer spectra of TiFe and sodium nitroprusside (SNP), the value obtained by the velocity-independent method is 1.699 mm/s for the SNP splitting, showing good agreement with the lower values obtained recently [4] by direct velocity methods. The values reported in the literature for direct velocity measurement methods have varied from 1.65 to 1.85 mm/s.

The NBS results make it possible to measure Knight shifts and chemical shifts of Fe in suitable alloys and compounds by the Mössbauer effect to about 0.5 percent or better. Although the accuracy is not comparable to nuclear magnetic resonance (NMR) results, which normally are used in measuring Knight shifts and chemical shifts, the new method will be valuable because the NMR of ^{57}Fe is often too weak to be observed.

Using TiFe as a reference material it is also possible to measure magnetic fields once the spectrometer has been calibrated in velocity units. This application of TiFe is expected to be especially valuable when the field is too inhomogeneous to do a nuclear magnetic resonance calibration and when Mössbauer effect studies are being done in a magnetic field.

[1] Swartzendruber, L. J., and Bennett, L. H., Mossbauer spectrometer calibration using TiFe, J. Res. Nat. Bur. Stand. (U.S.), **74A**, (Phys. and Chem.), No. 5 (Sept.-Oct. 1970).

[2] Swartz, J. C., Swartzendruber, L. J., Bennett, L. H., and Watson, R. E., Nuclear magnetic resonance of ^{57}Fe in the paramagnetic alloys $TiFe_{1-x}Co_x$, Phys. Rev. B **1**, No. 1, 146–152 (Jan. 1970).

[3] Bearden, J. A., Phys. Rev. **137**, B455 (1965).

[4] The details of this comparison are given in reference 1.

NSRDS NEWS

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

PHASE BEHAVIOR IN BINARY AND MULTICOMPONENT SYSTEMS

NSRDS-NBS-32, *Phase Behavior in Binary and Multicomponent Systems at Elevated Pressures: n-Pentane and Methane-n-Pentane* [1] (70 cents, SD Catalog No. C13.48:32), by V. M. Berry and B. H. Sage is the latest compilation in the NSRDS series. This publication is concerned with the critically evaluated data on the phase behavior of binary systems. It consists of three parts: first, the rationale of the evaluation process used; second, the behavior of *n*-pentane, and last, the behavior of the system methane-*n*-pentane. In their introduction, the authors state that the critical review of experimental data in the field of volumetric and phase behavior of pure substances and mixtures involves certain elements of judgment, particularly in regard to the actual in contradistinction to the stated uncertainties of measurement. Historical evidence is probably the best evidence, according to the authors, of the difference between the stated and actual uncertainties associated with experimental observations. Often precision is confused with accuracy even though an author has made a conscientious effort to appraise the uncertainties in each of the primary experimental variables involved. In this compilation, an effort was made to apply to the tabulated values realistic and conservative uncertainties that may seem unusually large when the claims of the investigators are considered.

The rationale for this conservatism is based on the authors' experience and judgment that accepted intensive properties of materials continue to change, with the passage of time, by amounts that are many times the original estimated uncertainties involved in the experimental work. On this basis the authors have generally employed rather large measures of uncertainty for the individual experimental data as compared to that which has been suggested by the original investigator. In addition, the uncertainties assigned to the final selected values have been set forth on what they believe to be a realistic basis. The authors fully explain and substantiate their approach to measures of uncertainty.

The properties of *n*-pentane considered are the critical constants and the vapor pressures and densities of the saturated coexistent phases as functions of temperature. For the methane-*n*-pentane system the compositions and densities of the coexisting phases are given as functions of temperature and total pressure. Data for the unique states of the two-component system are also presented. The reliability of the selected values and the differences between the selected values and various measured values are discussed, and a list of references is included.

BIBLIOGRAPHIC SERIES

The primary aim of the NSRDS program is to provide compilations of critically evaluated numerical data. These tables are published in the NSRDS-NBS series, which is one of the established publication series of the National Bureau of Standards, as well as through other appropriate channels. A necessary preliminary step to the critical evaluation process is the retrieval from the world's scientific literature of all papers falling within the technical scope of the particular effort. Each data center or compilation project therefore builds up a comprehensive, well-indexed bibliographical file that forms the base for the evaluation task. Because these bibliographical records are potentially of value to many research workers and others interested in the particular technical area, it is desirable to make them generally available. The Office of Standard Reference Data has therefore inaugurated a bibliography series (NBS-OSRDB) as a service to the technical community to make these files more readily available. Most of the bibliographies will be made available through the Clearinghouse for Federal Scientific and Technical Information, Sills Building, Springfield, Va. 22151. The first two bibliographies in this new series are available from the Clearinghouse.

High Pressure Bibliography

High Pressure Bibliography 1900–1968 [2] is a compilation by L. Merrill,

High Pressure Data Center, Brigham Young University, Provo, Utah, and is in two volumes, NBS-OSRDB-70-1-V1 and 70-1-V2 (Vol. 1, PB-191174, Microfiche 65 cents, Paper Copy $7; Vol. 2, PB191175, Microfiche 65 cents, Paper Copy $7). Volume 1 consists of Section I, Bibliography, and Section II, the Author Index, while Volume 2 is the Subject Index.

The Bibliography is a compilation of references to scientific papers published in the field of high pressure research from 1900 through 1968. It is concerned principally with the fields of chemistry, physics, geology, mechanics, and biology. Some of the major areas of research under these fields are:

1. Electronic Transport Properties
2. Magnetic Properties and Phenomena
3. Physical Properties
4. Mechanical Properties
5. Quantum Phenomena
6. Nuclear and Electronic Resonance Phenomena
7. Superconductivity
8. Thermodynamic Properties and Phenomena
9. Geological and Geophysical Properties
10. Chemical Properties and Reactions
11. Biological Studies

The pressure range is divided into two regions—static and dynamic. Most of the work cited in this bibliography falls in the pressure range of 5 to 80 kbars. The Bibliography contains 10 331 complete references alphabetized by first author. The Author Index is an alphabetical listing of all authors. Each index entry contains the author's name and the reference code associated with each of his contributions. Since the Bibliography is indexed only by first author, the Author Index is the means by which one can locate contributions of each author regardless of the position of his name in the author by-line. The Subject Index is arranged alphabetically by the key word appearing in the title.

Methods for Molecular Calculations-Bibliography and KWIC Index

NBS-OSRDB-70-3, *Semiempirical and Approximate Methods for Molecular Calculations—Bibliography and KWIC Index*[2] (AD705110, Microfiche 65 cents, Paper Copy $3), was compiled by George A. Henderson and Sandra Frattali, Georgetown University, Washington, D.C. Most research papers appearing in this bibliography fall in the area of non-*ab initio* calculations on the electronic states of small molecules. The papers included are those abstracted in *Physical Abstracts* from 1960 to May 1969, with a few additional entries earlier than 1960.

Many items in the bibliography are not given by title; rather, the compilers have made an attempt to include as much information as possible in a one-line description. All molecules for which calculations were performed are explicitly included in the entry for a given paper. The KWIC Index follows the bibliographic listing and provides a subject index in which all words appearing in document descriptions are arranged alphabetically and displayed in context. A desired document can be located by its document reference number in the bibliography.

NBS ALLOY DATA CENTER TRANSLATIONS

The Alloy Data Center has recently had two handbooks translated into English.

1. *Handbook of Binary Metallic Systems,*[2] by A. E. Vol (translated from the Russian), is in two volumes. (Volume I, TT66-51149, $9.48; Volume II, TT66-51150, $11.88.) This handbook is not complete in all binary systems. On the other hand, it gives more data for various physical properties than is given in the Hansen-Elliot-Shunk books on binary phase diagrams. Volume I (1959) is 635 English pages in length, and covers approximately 250 binary systems of Ac, Al, Am, Ba, Be, B, and N. Volume II (1962) is 870 English pages in length, and covers approximately 350 binary systems of Bi, Dy, Eu, Fe, Ga, Ge, H, Hf, Ho, V, and W. Information given, in addition to the phase diagram itself, may include crystal structures, mechanical properties, physical properties (such as density, electrical resistance, thermal conductivity, and heat capacity), chemical properties, and corrosion resistance. References to the literature are given with the description of each system.
2. *A Compendium of Constitutional Ternary Diagrams of the Metallic Systems*[2] (TT69–55069, $10) by W. Guertler, M. Guertler, and E. Anastasiadias (translated from the German). This handbook contains translations of all three parts originally published in 1959 under a U.S. Air Force contract.

   Each of the compilation's three parts includes binary and ternary diagrams of a given group of metals. Part I covers all of the binaries and ternaries formed between nine metals—Mn, Fe, Co, Ni, Cu, Pd, Ag, Pt, and Au. Part II covers all of the binaries (except those included in Part I) between Mg, Al, Si, Mn, Fe, Ni, Cu, and Zn, but only six of the possible ternaries, all of which contain Al as one of their constituents. Part III includes some of the ternary systems not found in Part II, plus other miscellaneous binary and ternary systems.

   The presentation for each binary or ternary system includes not only the phase diagram, but a commentary on sources of information and data reduction techniques, together with a bibliography. Both spatial constructions and isothermal sections are used to show the ternary diagrams. Crystallographic data are generally not given.

ALLOY DATA CENTER COMMENTS

As a service to the Committee on Alloy Phases of the Metallurgical Society, American Institute of Mechanical Engineers, the NBS Alloy Data Center has undertaken to publish a series of sheets entitled *Comments*. *Comments* deals primarily with questions of nomenclature in the presentation of alloy data. The first issue published in June 1970 presents a set of detailed comments by E. M. Levin of NBS on the proposed "Recommended Practice for Presentation of Phase Diagrams of the American Society for Testing and Materials" (E391-69). The loose-leaf form of *Comments* is intended to encourage filing for future use. The Alloy Data Center wishes to emphasize that *Comments* should be viewed as private communications only and no reference should be made to any views expressed in the comments without permission of the author. *Comments* is considered a forum for communication, and discussion of the views presented is solicited. All responses should be sent to L. H. Bennett, Room B152, Materials Building, National Bureau of Standards, Washington, D.C. 20234.

THE MASS SPECTROMETRY DATA CENTRE

The Mass Spectrometry Data Centre at A.W.R.E., Aldermaston, Berks., U.K., makes its services available internationally to all users of mass spectrometry in chemistry, physics, geology, and biology.

The main activities of the Data Centre are:

1. The publication of the *Mass Spectrometry Bulletin.*
2. The collection and distribution of new spectral data.
3. The experimental identification of chemical compounds by computer matching of mass spectra.

The Centre enjoys the benefit of an International Advisory Committee consisting of experts from the United States, France, Germany, Japan, and the United Kingdom.

The Centre commenced operations in 1966 and is supported jointly by the U.K. Office for Scientific and Technical Information and by the Ministry of Technology.

The Centre publishes the *Mass Spectrometry Bulletin,* a computerized monthly guide to the current literature of mass spectrometry and allied subjects. Each month more than 220 primary journals are scanned, together with reports, patents, abstract journals, and books in all languages. Information of interest to mass spectroscopists is collected and entered in the Bulletin. A main feature of the Bulletin is its specially designed indexes, including one on chemical compounds, to help speedy location of relevant items. Thirty-six hundred references were published in 1967, rising to over 5000 in 1968. The Bulletin is distributed through the British Information Services, 845 Third Avenue, New York, N.Y. 10022, or Her Majesty's Stationery Office, P.O. Box 569, London S.E.1, England. The annual subscription for 12 issues and a cumulated annual index issue is $74.50. The Mass Spectrometry Data Centre will supply sample copies on request. The Bulletin is also available on magnetic tape; inquiries should be sent to the Centre.

The Centre acts as the collecting point for mass spectra contributed from all over the world and issues these as data sheets (cost £25 per thousand, excluding postage) and on magnetic tape (cost £60 per thousand, excluding postage). Three thousand spectra are now available. A tape containing over 6000 spectra from the ASTME-14, Dow Chemical Co., American Petroleum Institute, and Manufacturing Chemists Association collections is available in the same format at £160.

All tapes are available in a number of forms, for example, 7 or 9 track, BCD or EBCDIC, to suit a wide variety of computer facilities.

Inquiries for data sheets and tapes should be made directly to The Mass Spectrometry Data Centre, Building A8.1A, A.W.R.E., Aldermaston, Reading RG7 4PR, United Kingdom.

[1] Order by SD Catalog number from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

[2] Order by PB, AD, or TT number from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, for the price indicated.

MICROGRAPHS *continued*

by SADIE is required, the machine is used as a scanner alone, feeding digital information to a 7-channel magnetic tape recording unit for later input to a computer. In this mode the scanner has been applied to aerial photographs, Post Office materials, and other subjects requiring analysis methods different from those used for microstructures.

[1] Moore, G. A., **Design of a practical scanner unit for precision analysis of micrographs,** Pattern Recognition (in press).

[2] **Processing pictorial information on digital computers,** Nat. Bur. Stand. (U.S.), Tech. News Bull. **42,** 60-63 (Apr. 1958).

[3] **Graphite particles in cast iron,** Nat. Bur. Stand. (U.S.), Tech. News Bull. **47,** 223 (Dec. 1963).

[4] **Digital computer used for quantitative metallographic analyses,** Nat. Bur. Stand. (U.S.), Tech. News Bull. **47,** 26-28 (Feb. 1963).

[5] **FOSDIC IV reads microfilmed weather data for computer,** Nat. Bur. Stand. (U.S.), Tech. News Bull. **51,** 63-65 (Apr. 1967).

[6] **MAGIC, Computer system reads diagrams drawn on screen,** Nat. Bur. Stand. (U.S.), Tech. News Bull. **50,** 134-136 (Aug. 1966).

NBS ISSUES RESEARCH MATERIALS

Ultra-Purity Aluminum–First RM

A NEW CLASS OF MATERIALS is now being issued by the NBS Office of Standard Reference Materials to meet the needs of scientists engaged in materials research. These new materials —Research Materials (RM's)—are in addition to and distinct from the Standard Reference Materials issued by NBS.

Efforts among different laboratories to measure the properties of a material or to design and fabricate new devices based on such a material have often proved fruitless or produced widely divergent results. Usually after a considerable investment of time and energy, the researchers have found that the material, presumably identical for all investigators, was in fact quite variable or nonhomogeneous in composition, or that new lots of the material differed considerably from previous ones.

To reduce such problems and to provide materials researchers with better starting points for their investigations, the Bureau is issuing Research Materials—the first of which is Ultra-Purity Aluminum. Unlike the Standard Reference Materials (SRM's) issued by the Bureau, the new RM's are not issued with Certificates of Analysis, rather they are accompanied by a "Report of Investigation," the sole authority of which is the author of the report.

The distinctions between Research Materials and Standard Reference Materials are the information supplied with them and purpose for which they are used. By definition, SRM's "are well-characterized materials that are certified for chemical composition or for a particular physical or chemical property." As such, SRM's are to be used to calibrate and evaluate measuring instruments, methods, and systems, or to produce scientific data that can be referred to a common base. A Research Material, on the other hand, is not a standard, and is intended solely for research on that particular material. The primary consideration in preparing an RM is to produce a highly homogeneous material so that an investigator in one laboratory will be assured that the material he has is the same as that being investigated in a different laboratory.

Criteria for Research Materials

Several important criteria must be met before a material is classified and issued as a Research Material.

1. There must be *demonstrated need* for the material or a written justification of the probable utility of the research material. One such need may be for specimens of higher purity, greater perfection, larger size, etc. in order to remove existing roadblocks to further advances. A second might involve acquiring baseline data on one or more properties, usually measured in several laboratories. The need would be for samples of a constant purity level, perfection, etc., even though these levels are not certified nor even known to a great degree of accuracy. In every case, however, some assurance concerning the degree of *homogeneity* of the material is required.

2. Commercially available materials will not, as a general rule, be available as an NBS Research Material. In special cases, where variations from lot to lot of commercial supplies are likely to occur, and where large-scale interlaboratory comparisons are involved, this rule may be suspended.

3. RM's will not be certified with regard to any property, chemical or physical. However, no RM will be issued unless a fair body of useful information on one or more important properties has been measured. RM's will be issued with a "Report of Investigation." The results and accuracy so reported are the sole responsibility of the author(s).

4. NBS will attempt to issue as RM's only those for which a reasonably large supply (taking into account the intended uses) of material is available. In any case, quantities remaining in stock will be noted in the SRM catalog.* NBS cannot guarantee to replace out-of-stock items, and indeed, by the very nature of the program will only do so in exceptional cases. Replacement lots in all likelihood may have different characteristics from the original lot.

To fulfill the purpose for which RM's are intended, purchasers of RM's will be encouraged to report their results and findings to NBS for distribution to other users of the RM. The Office of Standard Reference Materials will take responsibility for collecting incoming data and revising the "Report of Investigation" at reasonable intervals to include the new data. All such information will be in the public domain; no data or results labeled proprietary will be accepted by NBS.

Ultra-Purity Aluminum— First RM

The first Research Material to be issued by the Bureau is Ultra-Purity Aluminum, which is available in two forms. RM–1R is issued as round polycrystalline rods 0.164 in (4.17

*NBS Spec. Publ. 260, Catalog of Standard Reference Materials (July 1970 ed.).

mm) in diameter and 1 in (2.54 cm) long. RM–1C is issued as single crystal cubes approximately 0.4 in (1 cm) per side.

Well prepared and characterized materials are essential for meaningful research on the physical properties of pure metals. Some of these properties, such as grain growth, Seebeck coefficient, and magnetoresistance are critically dependent on the type and amount of contained impurities, even when the impurities are in the part-per-million range.

Ultra-Purity Aluminum is the first of a series of high-purity metals being prepared primarily for exacting physical research rather than for chemical analysis or physical standardization. There is a sufficient stock of the aluminum, both in single crystal cubes and in polycrystalline rods, that many experiments may be carried out on different specimens from the same homogeneous lot. With NBS as the source of homogeneous specimens, different researchers will be able to make intercomparisons on one property or correlations between different properties. The specimens may be used for accurate research on many properties such as: grain growth; deformation studies; electron microscopy imperfection kinetics; electrical, galvanomagnetic, or thermoelectric phenomena; superconducting transition temperature thermometry; thermal properties; and Fermi surface topology.

The polycrystalline rods are intended for use in providing specimens for research on the mechanical and physical properties of extremely pure aluminum, for example, in the determination of resistivity as a function of strain at cryogenic temperatures to facilitate the design of cryogenic magnets or superconductor stabilizing elements.

Ten rod specimens were measured and found to have a corrected residual resistivity ratio ($\rho 273\ K/\rho 4\ K$) varying from 15 540 to 17 310. The mean value for these rods is 16 160 with a standard deviation of 485. The inaccuracy of a single determination is estimated to be less than ± 3 percent. The estimated equivalent solute in solid solution based upon the corrected residual resistivity is 0.25 ppm atomic.

The single crystal material is intended for use in studies of a variety of solid state phenomena for which both extreme purity and knowledge of crystallographic orientation are required; e.g., in studies of electron spin resonance, De Haas-Van Alphen effect, cyclotron resonance, etc., and in a variety of studies relating to the Fermi surface and the transport properties of aluminum. The resistivity results for the single crystal cubes are in agreement with data obtained from the rod samples.

RM–1R and RM–1C are useful in studies of point and line defects and in studying the effect of such defects on the mechanical and physical properties of metals. The materials are also well suited for use in studies of grain boundary phenomena, for example, boundary structure, migration rates, and segregation phenomena.

Both forms are supplied in the annealed and chemically polished condition. Information on recommended annealing, etching, and polishing treatments is also available.

The rods, RM–1R, cost $50 per unit;[1] the cubes, RM–1C, $90 per unit.[1] The initial stock consisted of 41 units of RM–1R and 39 units of RM–1C. Additional material is available, but if processed, will be accompanied by a new Report of Investigation. The Office of Standard Reference Materials will send the complete Report of Investigation on request.

Besides the Ultra-Purity Aluminum, eight other high-purity metal RM's will be available in the near future. These are: tin, gold, silver, tungsten, molybdenum, a molybdenum alloy, a tantalum alloy, and a zirconium alloy. Other RM's will be prepared and issued when need for them has been demonstrated. New Research Materials will be announced in the *NBS Technical News Bulletin* as they become available.

[1] Research Materials may be purchased from the NBS Office of Standard Reference Materials, Room B308, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234, for the price indicated.

TIRE USAGE *continued*

overloading. But, like proper inflation, proper loading is not understood by most of the motoring public.

Tire Disablements

Tire failures—including puncture—comprise 40 to 60 percent of all vehicle breakdowns (excluding "out-of-gas" on expressways). A survey showed the yearly rate of tire disablement on the Illinois Tollway to be about 50 per million vehicle miles (mvm). The rate for the general passenger car in the Eastern States was double (100 per mvm), reflecting the higher incidence of bald tires among the general vehicle population as compared to throughway traffic. Assuming a disablement rate of 50 per mvm, and an average tread life of 20 000 miles, calculations show one new tire in four experiences some form of disablement during its useful life. Warranty claims are made against about 3 percent of new tires.

[1] Harvey, J. L., and Brenner, F. C., **Tire Use Survey—The Physical Condition, Use, and Performance of Passenger Car Tires in the United States of America**, Nat. Bur. Stand. (U.S.), Tech. Note 528 (May 1970). Two surveys, conducted under contract to NBS—Passenger Tire Use Survey, by the Dividson Laboratory, Stevens Institute of Technology, Hoboken, N.J., and Research Report on the Physical Condition of Passenger Vehicle Tires in Highway Use, by the Southwest Research Institute, San Antonio, Tex.—plus numerous other published and unpublished documents, form the basis of the material in this Technical Note. Tech. Note 528 is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, as SD Catalog Number C13.46:528 for 60 cents.

CONFERENCE *Briefs*

55TH NATIONAL CONFERENCE ON WEIGHTS AND MEASURES

The 55th National Conference on Weights and Measures was held in Salt Lake City, Utah, July 13–17, 1970, with an attendance of approximately 500. Among the significant actions taken by this year's Conference were major changes in the Model State Packaging and Labeling Regulation and the adoption of a Model State Lumber Regulation pertaining to dimensions for manufactured lumber. The new regulation on lumber covers advertising, selling, and invoicing in terms of actual instead of traditional dimensions of width, thickness, and length.

The National Conference on Weights and Measures, founded and sponsored by NBS, is an organization of weights and measures officials of the States, counties, and cities of the United States. The Conference brings together enforcement officials and representatives of business, industry, and trade associations for the purposes of developing model laws and regulations, adopting enforcement procedures, and considering the entire spectrum of weights and measures administration.

Twenty-eight speakers participated in the program, which included four open-forum sessions. The forum sessions covered the subjects of weighing and measuring technology, organization and management, packaging and labeling, impact of consumer programs, and highlights of the U.S. Metric Study. Among the many distinguished speakers were the Honorable Frank E. Moss, U.S. Senator, State of Utah; Dr. Myron Tribus, Assistant Secretary of Commerce for Science and Technology; Dr. Lewis M. Branscomb, Director, NBS; and Dr. A. J. Van Male, President, International Organization of Legal Metrology, and Director, National Service of Weights and Measures, Hague, Holland.

The Conference adopted numerous amendments to NBS Handbook 44, *Specifications, Tolerances, and Other Technical Requirements for Commercial Weighing and Measuring Devices,* in recognition of present day needs and design innovation. The Odometer Code, which had applied only to passenger vehicles, was amended to include odometers on trucks.

In response to a request from the National Motor Vehicle Safety Advisory Council the Conference agreed to support weights and measures participation, on a public service basis, in a national effort to upgrade the accuracy of air tower pressure gages used in service stations. The OWM engineering unit, working with the NBS Office of Vehicle Systems Research, has developed testing equipment, test methods, accuracy criteria, and other technical guidelines for weights and measures officials in the establishment of the program.

The Education Committee reported on current involvement by several States and the NBS Office of Weights and Measures in the use of computers in weights and measures administration. In addition, a subcommittee on computer technology was established and charged with the following activities:

a. Survey and determine the extent of programs now in operation at state level.

b. Establish goals for computer usage.

c. Establish standards for design of computer programs, including programming, coding, language, operations, and input and output parameters.

Copies of the Model State Law on Weights and Measures and of the Model State Packaging and Labeling Regulation as amended by the Conference will soon be available from the NBS Office of Weights and Measures. A report of the proceedings of the 55th National Conference on Weights and Measures will be published by NBS. Persons wishing to obtain a copy of the report or additional information on the National Conference on Weights and Measures should write to:

Harold F. Wollin, Executive Secretary
National Conference on Weights
and Measures
National Bureau of Standards
Room A737, Administration Building
Washington, D.C. 20234

SCHEDULED NBS-SPONSORED CONFERENCES

Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or cosponsored by NBS and will be held at the Bureau's Gaithersburg, Md., facility unless otherwise indicated. These conferences are open to all interested persons unless specifically noted. If no other address is given, inquiries should be sent to the person indicated below in care of Special Activities Section, Room A600, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

25th Calorimetry Conference. Oct. 19–22. Contact: E. Domalski (NBS Physical Chemistry Division).

4th Materials Research Symposium—Pyrolysis, Oxidation, and Burning. Oct. 26–30. Contact: L. A. Wall (NBS Polymers Division).

National Metric Study Conferences. Oct. 27–29 and Nov. 16–20. Contact: J. Odom (NBS Office of Invention and Innovation). To be held at Department of Commerce Auditorium, Washington, D.C.

The Science of Ceramic Machining and Surface Finishing. Nov. 2–4. Cosponsors: Office of Naval Research; Ameri-

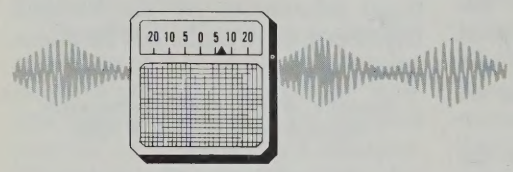
can Ceramic Society. Contact: S. J. Schneider (NBS Inorganic Materials Division).

Symposium on the Application of Computers to Environmental Engineering Design. Nov. 30–Dec. 2. Cosponsor: American Society of Heating, Refrigerating and Air Conditioning Engineers. Contact: R. Achenbach (NBS Building Research Division).

Flow—Its Measurement and Control in Science and Industry. May 10–14, 1971. Cosponsors: American Institute of Physics; American Society of Mechanical Engineers; Instrument Society of America. Contact: V. J. Giardina, Instrument Society of America, 400 Stanwix Street, Pittsburgh, Pa. 15222. To be held in Pittsburgh, Pa.

Summer Symposium in Analytical Chemistry. June 16–18, 1971. Cosponsor: American Chemical Society (Division of Analytical Chemistry). Contact: R. A. Durst (NBS Analytical Chemistry Division).

5th Symposium on Temperature Measurement and Control in Science and Industry. June 21–24, 1971. Cosponsors: American Institute of Physics; Instrument Society of America. Contact: H. H. Plumb (NBS Heat Division).



STANDARDS AND CALIBRATION

PRECISION MEASUREMENT AND CALIBRATION—HEAT

Precision Measurement and Calibration—Heat,[1] Defoe C. Ginnings, Editor, NBS Special Publication 300—Volume 6 (387 pages, $5; SD Catalog No. C13.10:300/Vol. 6) is one volume of a series bringing together previously published NBS papers in a particular field. This publication contains reprints through 1968 of selected NBS papers on heat. The collection supplements the papers on heat transfer and calorimetry that appeared in Volume II of NBS Handbook 77, published in 1961. A total of 29 papers are grouped under the following main topics: general calorimetry and techniques, cryoscopic measurements, low-temperature calorimetry, high-temperature calorimetry, reaction calorimetry, and heat transfer.

STANDARD FREQUENCY AND TIME BROADCASTS

High-frequency radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast time signals on the Coordinated Universal Time (UTC) system as coordinated by the Bureau International de l'Heure (BIH), Paris, France. The NBS time scale, UTC(NBS) and the U.S. Naval Observatory time scale, UTC(USNO) are jointly coordinated to within ±5 microseconds. The UTC pulses occur at intervals that are longer than one coordinate second by 300 parts in 10^{10} during 1970, due to an offset in carrier frequency coordinated by BIH. To maintain the UTC scales in close agreement with the astronomers' time, UT2, phase adjustments are made at 0000 hours Greenwich Mean Time (GMT) on the first day of a month as announced by BIH. *There will be no adjustment made on November 1, 1970.*

The low-frequency radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses without offset to make available to users the standard of frequency so that absolute frequency comparisons may be made directly, following the Stepped Atomic Time (SAT) system. Step time adjustments of 200 ms are made at 0000 hours GMT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be an adjustment made on November 1, 1970. The seconds pulses emitted from WWVB will be retarded 200 ms.*

NBS obtains daily UT2 information from forecasts of extrapolated UT2 clock readings provided by the U.S. Naval Observatory with whom NBS maintains close cooperation.

BROADCAST INTERRUPTIONS

The transmissions from WWV and WWVH are being interrupted intermittently during September and October to carry out antenna measurements. The interruptions are brief and affect only one frequency at a time. Both stations are making voice announcements about this between three and four minutes after each hour starting at 0000 UT on September 1, 1970, and continuing until about November 1, 1970.

[1] Order by SD Catalog Number from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Annual Subscription: Domestic, $3; foreign, $4. Single copy price 30 cents. Available on a 1-, 2-, or 3-year subscription basis. SD Catalog No. C13.13:54.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $9.50; foreign, $11.75. Single copy price varies. SD Catalog No. C13.22/sec.A:74.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25. SD Catalog No. C13.22/sec.B:74.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25. SD Catalog No. C13.22/sec.C:74.

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Eisele, J. W., Technical Standards Coordinator, Horticultural grade perlite, Nat. Bur. Stand. (U.S.), Prod. Stand. 23-70, 9 pages (May 1970) 10 cents, SD Catalog No. C13.20/2:23-70.

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Robbins, D., Englert, A. J., ed., Disclosures on: Viscous damped wind vane; nonskid road or runway; regrooved pneumatic tire with removable inserts; device for radially positioning a rotating wheel; method for fabricating precision waveguide sections; distortion-cancelling loudspeaker system; cryogenic fluid density measurement system; and controlled-atmosphere weathering device, Nat. Bur. Stand. (U.S.), Tech. Note 536, 25 pages (June 1970) 35 cents, SD Catalog No. C13.46:536.

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